

UNITED STATES DEPARTMENT OF AGRICULTURE

Soil Survey
of
The Clear Lake Area, California

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SOIL SURVEY

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AREA SURVEYED

The Clear Lake area is in the central part of Lake County, Calif., which lies in the midst of the Coast Range, about 70 miles north of San Francisco Bay, about midway between the Pacific Ocean on the west and the Sacramento Valley on the east. The area surveyed includes the lands adjacent to Clear Lake and the headwaters of Putah Creek. These lands constitute most of the agricultural land of the county. Exclusive of the area occupied by Clear Lake, 386 square miles, or 247,040 acres, have been surveyed and mapped. The base map was constructed by the field party by means of plane-table traverse, and an automobile speedometer was used for measuring distances.

The area is marked by rather distinct physiographic features. The central part is occupied largely by Clear Lake, a natural mountain lake, which in time of high water, drains through Cache Creek into Sacramento River. The flow from this lake is controlled for irrigation purposes by a dam in Cache Creek near the eastern boundary of the area. The lake is about 17 miles long, from east to west, and varies from about 1 mile to 6 miles in width. Mount Konokti, one of the prominent peaks of the Coast Range, with an elevation of more than 4,100 feet, rises abruptly from the southern shore of the lake near the central part of the area. Prominent spurs of the Coast Range hem the lake in on all sides, and drainage ways issuing from the mountains have built alluvial fans and terraces which rise with increasing gradient or successive steps to meet the foothills or precipitous mountain slopes. Among other less important lakes are Lower Blue Lake, Thurston Lake, Borax Lake, and Little Borax Lake.

To the west of Mount Konokti, sediments from Cold Creek, Kelsey Creek, and Adobe Creek have built up a comparatively large alluvial plain known locally as Big Valley. Scotts Valley to the west of Clear Lake is another important valley. Middle Creek, Scott Creek, and Clover Creek in the northern part of the area have important valley features and have built an alluvial plain debouching on the lowlands bordering the lake. Elsewhere along the lake is a narrow



FIGURE 1.—Sketch map showing location of the Clear Lake area, Calif.

fringe of alluvial sediments deposited by minor drainage ways entering the lake. Important valley features are also developed along Putah Creek and its tributaries in the southeastern part of the area.

Clear Lake lies at an elevation of about 1,300 feet. However, the water level of the lake varies several feet from season to season, owing to the removal of water through a dam on Cache Creek which impounds water for the irrigation of lands in the Sacramento Valley. The valley lands of the area range in elevation from 1,400 to more than 1,500 feet above sea level, and the included mountainous areas attain an elevation ranging from 2,000 to 4,000 or more feet.

The drainage of the area is very largely into Clear Lake, through Scott, Middle, Cold, and Kelsey Creeks. Cache and Putah Creeks drain eastward into Sacramento River. No drainage from the area flows westward directly to the Pacific Ocean.

Throughout the mountainous part of the area are a number of small, intermittent lakes which contain from several inches to a foot or more of water as soon as the rainy season begins and remain wet until nearly midsummer. Drainage is poor in Big Valley, bordering Clear Lake, and near the mouths of Middle and Scott Creeks. The water table in these localities is at or near the surface during the rainy season, but drops several feet by midsummer. In High Valley, which was once occupied by a lake but is now drained owing to headward erosion of a small stream tributary to Clear Lake, drainage is still rather poor during the rainy season. Drainage is also poor in an area lying north of the southern end of Clear Lake, locally known as Wagners Flat, where most of the soils are water-logged throughout the winter. Throughout the foothills and upper terraces drainage is in general well developed, and the soils can be worked soon after the rains cease.

Most of the streams in the mountainous parts of the area are swift flowing, but before reaching the lake they generally fan out over the bottom lands, and drainage waters reach the lake as sheet water or through shallow channels.

On May 20, 1861, Napa County was divided and a new county was formed and given the name of Lake, because of the great number of lakes within its boundaries. Since the formation of the county several changes in its boundaries have been made by annexation to or from bordering counties. The early settlers came largely from the Central and Eastern States. Most of the inhabitants are American born and of Anglo-Saxon extraction. A number of Indian tribes roamed the county in the early days, but at present few remain and these are segregated on Indian rancherias. The valley section of the county is rather thickly populated, especially in the vicinity of Lakeport, Kelseyville, and Upper Lake. Elsewhere the rural sections are thinly settled. During the summer months the county is a favorite recreation spot for tourists and people from adjacent valleys and cities. The population of the county as given in the 1920 census is 5,402, and most of the people reside in the area surveyed.

Lakeport is the county seat of Lake County and the principal town in the area, having a population of 1,024 in 1920. Upper Lake and Middletown provide schools, churches, banks, and trad-

ing points for the settlers in the northern and southern parts of the area, respectively. Lower Lake, near the eastern end of Clear Lake, also has schools, churches, and business houses serving the local population. Kelseyville, near the center of the area, provides a trading center and modern conveniences to the adjacent highly developed fruit section. A number of other small towns or summer settlements border Clear Lake and Lower Blue Lake, and some are in the mountains in the southern and western parts of the area near the numerous mineral springs.

Owing to the rough topography of Lake County, no railroad has been built into the area. The Northwestern Pacific Railroad, operating between San Francisco and Eureka, passes up Russian River, and good oiled roads connect the Clear Lake area with this railroad at Hopland and Ukiah in Mendocino County. A good road also leads from Middletown to Calistoga, Napa County, a distance of 16 miles, where connections are made with a branch of the Southern Pacific Railroad and the Napa Valley Railroad (electric).

There are no paved roads in the area, but all the principal highways are graveled and are kept in fair or good condition throughout the year. Many of the minor roads are wet and almost impassable during the rainy season. Telephones are in general use throughout the area, and electricity is now available in all the better-developed sections.

CLIMATE

The climate of the Clear Lake area is, in general, mild, though during the summer some extremely hot days occur when the thermometer may range from 100° to 109° F. Hot spells, however, are of short duration. The summers are dry with moderately high temperatures and the winters mild with moderate rainfall.

The rainy season commences in October and continues until late in May. More than 50 per cent of the annual rainfall occurs during December, January, and February. During the summer and early fall little or no rain falls, and week follows week with clear cloudless skies and uniformly warm temperatures. During the winter the rains are generally accompanied by southeast winds which may continue for several hours or days and be followed by clear warm days. The mean annual precipitation at Upper Lake is 28.51 inches, and this figure is fairly representative of rainfall data for the valley parts of the area. At higher points the rainfall is correspondingly higher.

The mean annual temperature at Upper Lake is 57.4° F. In the mountainous parts of the area, the summer temperatures are lower and the days are tempered by cool refreshing breezes. During the summer there is generally a light breeze from the ocean during the afternoon, continuing until sundown. Heavy winds are rare, though they occasionally blow for short periods during the spring and fall.

Light snowfalls occur during most winters, but the snow usually melts as it falls or lasts for only a few days. It is never sufficient to injure sheep and cattle pasturing in the mountains. Fogs are infrequent but sometimes occur during the winter.

The average date of the last killing frost at Upper Lake is April 2 and of the first is November 6. This gives an average frost-free season of 218 days. Frosts have been recorded, however, as late as May 2 and as early as September 29. Early and late frosts sometimes do considerable damage, especially in the spring when the fruit buds may be killed. Most orchardists have made provision for orchard heating to prevent frost damage.

In a few well-protected sections of the area where air drainage is good some citrus fruits can be produced. Figs are successfully grown in many localities. Pears and walnuts are two crops which are well suited to the prevailing climatic conditions. Alfalfa, grain, and the general farm crops are well suited to the climate of the area.

Table 1, compiled from the records of the United States Weather Bureau station at Upper Lake, gives the normal monthly, seasonal, and annual temperature and precipitation for the area.

TABLE 1.—*Normal monthly, seasonal, and annual temperature and precipitation at Upper Lake, Calif.*

[Elevation, 1,350 feet]

Month	Temperature			Precipitation		
	Mean	Absolute maximum	Absolute minimum	Mean	Total amount for the driest year (1898)	Total amount for the wettest year (1909)
	^{°F.}	^{°F.}	^{°F.}	<i>Inches</i>	<i>Inches</i>	<i>Inches</i>
December.....	44.1	78	16	5.08	1.34	4.85
January.....	43.5	84	13	6.99	.93	21.34
February.....	46.3	83	13	4.54	4.57	8.19
Winter.....	44.6	84	13	16.61	6.84	34.18
March.....	51.0	90	22	3.80	.36	2.61
April.....	54.8	93	25	1.67	.43	.00
May.....	59.6	102	29	1.22	1.90	(¹)
Spring.....	55.1	102	22	6.69	2.69	2.61
June.....	66.8	103	35	.25	.58	.17
July.....	73.8	109	40	.03	.00	.00
August.....	72.8	109	37	.03	(¹)	.00
Summer.....	71.1	109	35	.31	.58	.17
September.....	66.7	106	28	.47	.60	.95
October.....	58.8	101	23	1.36	1.01	1.84
November.....	50.7	90	22	3.07	1.66	4.18
Fall.....	58.7	106	22	4.90	3.27	6.97
Year.....	57.4	109	13	28.51	13.38	43.93

¹ Trace.

AGRICULTURE

Hunters and trappers of the Russo-American Fur Co. were the first white men, of whom there is any record, to invade the territory adjacent to Clear Lake. Wild game abounded, and the trappers and hunters were attracted here as early as 1811.

About 1840 ¹ Salvador Vallejo took possession of much of the territory now known as Big Valley and started agricultural activi-

¹ PALMER, L. L. HISTORY OF NAPA AND LAKE COUNTIES, CALIFORNIA, AND BIOGRAPHICAL SKETCHES. 600+291 p., illus. San Francisco. 1881.

ties. It was not until about 1850, however, that settlement began in earnest. By 1854 settlers began to arrive in considerable numbers and it was not long before the valley parts of the area were largely under private ownership, generally in large holdings. On May 20, 1861, Lake County was organized and Lakeport was made the county seat. This town is still the only incorporated town in the area.

Following the occupation of the valley lands, it was not long before the dairy industry began to assume importance. The county assessor's books in 1868 show that 28,500 pounds of butter and 23,056 pounds of cheese were produced in the county in that year. Only 506 beef cattle were listed at that time. Barley which occupied 2,050 acres, oats 250 acres, and corn 400 acres were produced largely in connection with the dairy industry. Wheat occupied 5,002 acres, and, because of the difficulty of transporting bulky products, several flour mills were built and the wheat was milled for local consumption and for outside sale.

The fruit industry had begun to assume some importance as early as 1868. There were at that time 1,200 pear trees, 10,400 apple trees, 6,542 peach trees, and 40 walnut trees in the county. Prunes were planted extensively during the early eighties, but with the decline in prices in later years many of the trees were pulled out.

Bartlett pears, for which the area is now best known, were first grown about 1885. Pears are the principal commodity produced in excess of local demand. (Pl. 1, A.) They are marketed principally in the Central and Eastern States, where they command a good price. Some prunes, walnuts, and grapes also are marketed outside the area.

The pear orchards are plowed or disked early in May or as soon as moisture conditions are favorable. They are then given clean cultivation throughout the summer. During the rainy season weeds and volunteer grasses cover the soil and are plowed under in the spring. Some better-cared-for orchards are planted to cover crops which are plowed under in the spring to increase the organic-matter supply. During the growing season the orchards are watched constantly for pear blight, and any affected limbs are cut out and burned. This disease is a constant menace to the orchards, but so far it has been kept under control and has not proved serious. The orchards are sprayed two or three times during the spring for the control of the codling moth, consequently few wormy pears are found. The pears are picked early in September and hauled to packing houses where they are graded and packed preparatory to shipment to outside markets. The larger-sized pears are dried or shipped to local markets.

Most of the grain produced is harvested with a combine, and, owing to the expense of hauling to a transportation point, it is largely consumed locally.

United States census data are available for Lake County as a unit and since, with the exception of a few very small areas, the area surveyed embraces the agricultural lands of the county, the county data will be used for presenting agricultural statistics.

The census for 1880 shows 512 farms in the county, including an average of 323 acres, of which 139.4 acres is improved land. Orchard

products were valued at \$13,957, market-garden products at \$9,505, and forest products at \$42,783. Corn occupied 755 acres, wheat 8,296 acres, barley 4,551 acres, and oats 352 acres. Hay occupied 10,998 acres and produced 13,180 tons. Wheat yielded an average of about 21 bushels to the acre, barley 30 bushels, and oats 34 bushels.

The value of all agricultural products in 1919 was \$2,729,984. The value of the fruit and nut crop alone was \$662,977. The number of pear trees had increased to 85,776, more than double the number in the county in 1909. There were 33,361 nut trees in the county in 1919, of which 3,463 were walnuts.

At the present time the agriculture of Lake County consists of the growing of fruit, general farming, dairy farming, and some truck gardening. The principal fruits grown are pears, prunes, and grapes. Walnut culture is assuming more importance from year to year. The Mayette and Franquette varieties produce an excellent quality of nut and seem well suited to local conditions. Alfalfa is the principal hay crop. Cereal crops are grown largely on land not suited to fruit or alfalfa production. The yields of cereals remain nearly the same as in former years.

The number of farms is increasing, but the acreage in farms has decreased somewhat, indicating the more intensive development of smaller acreages. The large acreage in farms in 1920, also the large acreage devoted to wheat in 1919 and 1920 are owing largely to the agricultural stimulus of the postwar period.

Farmers in the Clear Lake area recognize that the soils of the Rincon, Cole, Clear Lake, Dublin, and Yolo series are best suited to pear production. The soils of the Aiken, Konokti, Rincon, and Yolo series are generally recognized as the best walnut soils; grapes and prunes are grown extensively on the Manzanita and Pinole soils; truck gardening is carried on largely on the Bayside soils; and alfalfa and hops are grown almost exclusively on the Yolo soils.

Land to be seeded to wheat, oats, or barley is plowed in the fall as soon as moisture conditions are favorable and seed is sown the same fall. Harvesting is done with a combine during the early summer, after which the fields are pastured. The orchards are clean cultivated throughout the summer but are allowed to grow up to weeds or native grasses during the winter. Sometimes a cover crop is planted. The orchards are plowed lightly or disked in the spring as soon as moisture conditions allow. Alfalfa fields are pastured during the winter, but as soon as the crop begins to make rapid growth in the spring the livestock are turned out of the fields and the crop is cut on an average of twice a season for hay with a fall cutting for seed. The fields are generally left in alfalfa for five or six years. They are then plowed and planted to grain for a year or two, then returned to alfalfa.

Less than 3 per cent of the farms of the county reported the use of commercial fertilizer in 1919. The fertilizer used consists largely of lime, which is applied to the pear orchards. Less than \$75 a farm was spent for fertilizer in that year.

Most of the farm buildings throughout the area are modern and in good repair. The light or medium weight tractor is in universal use and other farm machinery is modern and generally well cared for. Work animals are of light or medium weight. A few head

of cattle are kept on most of the general farms, but on many farms devoted exclusively to orcharding no livestock is kept. Beef cattle are largely of the Hereford breed, and dairy cattle are mainly of the mixed breeds. Automobiles and autotrucks are in use on nearly every farm. Telephones and electric lights are in use on the majority of the ranches.

Labor is plentiful and largely American born. During the fruit-picking season much labor is employed, consisting mainly of people who follow the fruit harvest from one section of the State to another. Such labor is, in the main, highly efficient.

Most of the fruit ranches are small or of medium size, the average ranch including about 50 acres. Ranches devoted to general farming or livestock raising include from 300 to 1,000 or more acres. The average size of farms in Lake County is about 300 acres.

In 1920, 82.2 per cent of the farms of the county were operated by owners, 16.1 per cent by tenants, and 1.7 per cent by managers. Renting is generally done on the share system, the owner receiving one-fourth of the crop and the tenant the remainder. The tenant furnishes labor, fertilizer, implements—in fact, everything except the land.

Soils of the Yolo and Bayside series are the most valuable agricultural soils in the area. Soils of the Rincon and Cole series are valued highly and are generally well developed. In general, soils of the Manzanita series are valued somewhat higher than those of the Pinole series. The Dublin and Clear Lake soils are of about equal value, though, on account of restricted drainage they are not regarded so highly for pear production as other soils devoted to this crop. The soils of the Aiken and Konokti series are increasing in favor each year as walnut land, but the cost of clearing is high. Soils of the Hugo, Butte, Klamath, and Holcomb series are not extensively developed and are generally considered of low agricultural value.

The Clear Lake area is unfavorably situated with regard to transportation facilities. The cost of trucking products out of the area to a shipping point ranges from \$5 to \$6 a ton, depending on the accessibility of the ranch. Under future development attention should be paid to the production of the less bulky commodities suited to the region which have a high value per unit of weight. The success attendant on walnut culture in this region suggests this crop as of value for future development. The crop is best suited to deep, well-drained soils of loose, friable consistence, and no attempt should be made to grow walnuts on shallow or poorly drained soils. It is essential for continued successful orchard practices that plant food be returned to the soil. The turning under of stable manure where available, or the growing of leguminous cover crops such as vetch or bur clover should be practiced when possible. Best results with commercial fertilizer will be obtained if the soils are well supplied with organic matter. A hard, compact layer, commonly known as a plow sole, is prevalent in the majority of the orchards of the area; also in many fields devoted to general farm practices. Subsoiling to a slight depth and other methods are used to break up this plow sole and thereby improve crop yields. Greater diversification of crops is advisable. The Clear Lake area is well suited to dairying, and it is suggested that this industry be further developed. Care should be

exercised to maintain the quality of the dairy herds by keeping individual production records. Sheep, swine, and poultry thrive and offer considerable opportunity for profit in connection with other farming operations.

Table 2 is of interest in showing the cost of production of pears, one of the principal commodities produced in the area.

TABLE 2.—*Cost-of-production study on full-bearing Bartlett pear orchards in Lake County, Calif., in 1926*¹

SUMMARY OF INVENTORY PER ACRE

Item	Average investment	Interest at 6 per cent	Depreciation for year	Total charge
Trees.....	\$304.09	\$21.88	\$12.03	\$33.91
Improvements.....	15.00	.94	1.03	1.97
Equipment.....	45.55	2.38	6.33	8.71
Land.....	251.66	15.10	-----	15.10
Total.....	677.50	40.30	19.33	59.69

SUMMARY OF EXPENSES

Operation	Average labor cost per acre	Average material cost per acre	Average total cost per acre	Average cost per ton
Pruning.....	\$19.63	-----	\$19.63	-----
Bracing.....	1.75	\$0.46	2.21	-----
Dormant spray.....	2.36	3.36	5.72	-----
Spring spray.....	4.97	3.39	8.36	-----
Cover crop.....	.40	.56	.96	-----
Cultivation.....	12.30	.46	12.76	-----
Inarching.....	.59	-----	.59	-----
Irrigation.....	7.97	3.80	11.83	-----
Harvesting.....	50.88	5.41	56.29	-----
Blight control.....	1.38	-----	1.38	-----
Drainage.....	.79	-----	.79	-----
Thinning.....	1.92	-----	1.92	-----
Labor insurance.....	1.43	-----	1.43	-----
Miscellaneous.....	3.61	1.99	5.60	-----
Total.....	109.98	19.49	129.47	\$12.56
General expenses.....	-----	5.42	5.42	.63
County taxes.....	-----	-----	12.10	1.40
Total.....	-----	-----	146.99	14.59
Depreciation and interest on trees.....	-----	-----	33.92	3.92
Depreciation and interest on improvements.....	-----	-----	1.97	.23
Depreciation and interest on equipment.....	-----	-----	8.71	1.01
Total.....	-----	-----	191.59	19.75
Interest on investment in land.....	-----	-----	15.11	1.75
Total.....	-----	-----	206.70	21.50

¹ Data supplied by courtesy of L. C. Barnard, Lake County farm advisor.

Number of orchards, 17. Number of trees, 16,544. Acreage, 234.27.

	Production (tons)	Returns
Grade 1.....	1,485.95	\$58,394.10
Grade 2.....	9.50	273.50
Dryers.....	477.58	11,643.90
Culls.....	51.30	1,002.96
Total.....	2,024.33	71,314.46

Yield per acre, 8.65 tons. Return per acre, \$304.41.

SOIL SERIES AND TYPES

For the purpose of a better understanding of the occurrence and mode of formation of the different soils of the Clear Lake area, the different series are divided into the following four groups: (1) Soils developed on consolidated bedrock materials, (2) soils developed on old unconsolidated or old valley-filling materials, (3) recent alluvial soils, and (4) miscellaneous materials.

The soils of the first group have weathered in place from the underlying consolidated rocks. They occur on the mountain slopes and lower foothills of the area. According to differences in age and stage of weathering, color, lime content, or other obvious chemical or physical features, they have been classified in the Aiken, Konokti, Hugo, and Butte series.

The Aiken series includes soils having red or brownish-red, in some areas pale-red, surface soils overlying subsoils of similar or of slightly redder color. The subsoils are generally slightly or moderately compact and of somewhat heavier texture than the surface soils. In the Clear Lake area these soils are generally deeply weathered and of good agricultural value. They are derived principally from volcanic rocks of low quartz content including andesite, basalt, and obsidian.

Soils of the Konokti series are characterized by brown or reddish-brown surface soils overlying subsoils of the same or somewhat browner color. As mapped in this area these soils are derived largely from an andesite rock and they are pale yellowish brown or pale reddish brown in many places. As a whole, they are deeply weathered and of fair or good agricultural value.

In the Clear Lake area, soils of the Hugo series are characterized by dull-brown or light grayish-brown surface soils which show a perceptible shade of yellow in many places. The subsoils consist of dull grayish-brown, light-brown, or yellowish-brown material of similar or of somewhat heavier texture than the surface soil. Here and there a light reddish cast is developed in the subsoil. Bedrock consisting of shale or sandstone is reached at a depth ranging from 24 to 36 inches.

The Butte series includes soils with gray, dark-gray, or dark brownish-gray surface soils containing an appreciable quantity of sharp angular pumice fragments. The subsoils are of similar or of lighter-gray color than the surface soils. At an average depth of about 24 inches the soils rest on a pumice or tuffaceous bedrock substratum.

The old valley-filling materials have been transported by running water and deposited by present or former streams. Soils of this group occupy elevated stream terraces well above overflow and are derived from a variety of rocks. The soils which have been developed on these materials are generally well weathered and have tight compact subsoils. According to differences in color, character of surface soil and subsoil, drainage, lime content, or other chemical or physical features, they have been classified in the Manzanita, Pinole, Rincon, Cole, Holcomb, and Klamath series.

Soils of the Manzanita series are characterized by pale reddish-brown, brownish-red, or yellowish-red surface soils, which may contain an appreciable amount of small round iron-cemented pellets.

The upper part of the subsoil is pronounced reddish-brown or dull-red moderately compact material having considerable pore space; the lower part is a dense extremely compact bright-red or dull yellowish-red heavy-textured material containing a great number of well-weathered gravel which can be easily cut with a knife or soil hammer. The material lying deeper, generally below a depth of 6 feet, is pale-red or pale yellowish-red less compact but dense material which is somewhat lighter in texture than the material above. This layer also contains an abundance of well-weathered gravel.

Under virgin conditions, soils of the Pinole series are characterized by surface layers of granular light grayish-brown material, tinted with shades of yellow, ranging from faint to very pronounced. This material contains a few spherical shotlike iron pellets or concretions. The subsurface layer is light yellowish-brown or light-brown material which is firm in place but which breaks up into a granular mass. Owing to cavities left by the decay of plant roots and to insect or animal burrows the pore space is great. The upper part of the subsoil is dull-yellow or light yellowish-brown material which is slightly compact but breaks up readily to a cloddy structure. It contains less pore space than the overlying material. This layer is underlain by light yellowish-brown, pale-yellow, or dull-yellow material which is somewhat heavier in texture than the layer above. It is compact and contains many slightly weathered stream gravel. This layer grades into light yellowish-brown or yellow very gravelly and compact heavier-textured material. The gravel are well weathered and may be readily crushed under slight pressure. Below a depth of 5 feet is somewhat lighter-textured light-brown or somewhat yellow material, with a pronounced grayish cast, which is very compact but breaks out to a granular structure. The soils are slightly acid.

Soils of the Rincon series are characterized by rather dull grayish-brown or brown surface soils which are firm in consistence. To a depth of 1 or 2 inches, the surface layer, in virgin areas, is somewhat grayer than the underlying soil and is of small granular structure. The subsoil consists of two layers, the upper one of light-brown or brown moderately compact material of similar or only slightly heavier texture than the surface soil, and the lower one of light-brown or dull grayish-brown very compact heavier-textured material. The structure ranges from coarse cloddy to columnar, and dull-brown colloids coat the partings. (Pl. 2, A.) Below a depth of 5 feet the subsoil is light-brown or light grayish-brown material of about the same texture as the surface soil. It is compact and of firm, dense consistence.

The Cole series includes soils having medium grayish-brown or dull dark-brown surface soils. In some areas the surface soils are dull brownish gray. The upper part of the subsoil is of similar or slightly darker color and of similar or heavier texture than the surface soil, but it is more compact. The lower part of the subsoil is very dull-brown, dark-brown, or dark brownish-gray very compact heavy-textured material which in most places is mottled with gray, yellow, or rust brown. In many places the subsoil is more or less

stratified and may contain some strata of black soil material, and in other places it is calcareous.

Soils of the Holcomb series are characterized by light-brown, light reddish-brown, or yellowish-brown surface soils which are generally firm and dense and contain little organic matter. The upper subsoil layer to a depth ranging from 20 to 36 inches consists of decidedly compact material similar to or somewhat heavier in texture than the surface soil. The lower subsoil layer is distinctive and consists of drab or bluish-gray dense waxy clay which continues to a depth of 6 or more feet.

The Klamath series includes soils having gray, dark brownish-gray, or dark-gray surface soils which are firm but contain a very appreciable amount of pore space. When disturbed the material breaks down to a granular mass. The subsoil consists of dark-gray or bluish-gray clay loam or stiff waxy clay of pronounced columnar structure. (Pl. 2, B.) In some places the subsoil materials are somewhat stratified and include light-colored materials which appear to consist of very finely divided siliceous diatomaceous or volcanic ash.

The recent alluvial soils have been deposited in comparatively recent times by the streams which they border. The soils are generally overflowed periodically and are being built up or added to during each successive overflow. They are unweathered, and differences in the soil layers are due to stratification of deposition. The soils are predominantly loose and permeable to a depth of 6 or more feet, though some heavy-textured soils or strata of materials occur. Differences in color and other physical or chemical properties of the soils have given rise to four soil series, the Clear Lake, Dublin, Yolo, and Bayside.

The surface soils of members of the Clear Lake series consist of dark-gray or black material. The upper subsoil layer is similar in texture and color, perhaps somewhat darker and heavier, but it becomes grayer with depth, and at a depth ranging from 14 to 20 inches is decidedly calcareous.

The Dublin series includes soils with dark-gray or black surface soils overlying subsoils of the same or somewhat grayer color. Between depths of 20 and 30 inches the subsoil is, in many places mottled with rust brown, and in some areas the surface soils are mottled. Soils of the Dublin series are differentiated from the related Clear Lake soils by the absence of lime in the Dublin subsoil.

Soils of the Yolo series are characterized by brown, light-brown, or light grayish-brown surface soils overlying subsoils of similar color but of stratified structure. Both surface soils and subsoils are loose and friable, and easily penetrated by plant roots.

The surface soils of members of the Bayside series consist of dull brownish-gray or dull grayish-brown material mottled with rust brown and containing much organic matter in various stages of decomposition. The subsoils are dull-gray, dark brownish-gray, or dark-gray stratified material mottled with rust brown. This layer also contains much organic matter. In a few places the subsoil is bluish gray. The soils of this series represent recently emerged or reclaimed lake-laid deposits which are high in organic matter.

Included with the group of miscellaneous materials are rough mountainous land, rough stony land, and river wash, all of which are nonagricultural.

In subsequent pages of this report the different types of soil occurring in the Clear Lake area are described and their agricultural importance is discussed. In Table 3 are given the names, acreage, and proportionate extent of the soils mapped.

TABLE 3.—*Acreage and proportionate extent of the soils mapped in the Clear Lake area, Calif.*

Type of soil	Acres	Per cent	Type of soil	Acres	Per cent
Yolo fine sandy loam.....	2,496	1.6	Pinole gravelly fine sandy loam.....	2,816	1.1
Poorly drained phase.....	1,408		Konokti gravelly clay loam.....	13,824	
Yolo gravelly loam.....	7,360	3.0	Stony phase.....	640	5.9
Yolo loam, poorly drained phase.....	3,456	1.4	Hugo clay loam.....	11,712	
Yolo clay loam, poorly drained phase.....	640	.3	Shallow phase.....	5,952	7.1
Cole fine sandy loam.....	3,264		Aiken clay loam.....	3,520	
Gravelly phase.....	1,344	2.4	Aiken gravelly clay loam.....	7,808	4.3
Heavy-textured phase.....	448		Stony phase.....	2,688	
Calcareous-subsoil phase.....	1,024	.6	Bayside silty clay loam.....	1,792	1.4
Cole clay loam.....	1,472		Calcareous-subsoil phase.....	1,728	
Rincon loam.....	5,056	2.0	Butte gravelly sand.....	1,920	.3
Rincon gravelly sandy loam.....	4,416	3.1	Klamath silty clay loam.....	4,352	
Reddish-brown phase.....	3,136		Gravelly phase.....	768	2.1
Rincon very fine sandy loam.....	1,664	.7	Holcomb clay loam.....	1,280	
Clear Lake clay adobe.....	5,504	2.5	Rough mountainous land.....	106,752	43.2
Upland phase.....	768		Rough stony land.....	18,752	
Dublin clay adobe.....	1,600	.6	River wash.....	896	.4
Manzanita clay loam.....	6,144	2.5	Total.....	247,040	-----
Manzanita gravelly fine sandy loam.....	1,856	.7			
Pinole loam.....	6,144	2.8			
Gray phase.....	640				

YOLO FINE SANDY LOAM

The 6 or 8 inch surface layer of Yolo fine sandy loam consists of dull-brown or light grayish-brown fine sandy loam which is loose and friable and easily maintained in good tilth. The subsoil, which continues to a depth of 72 or more inches, is dull-brown or light grayish-brown, loose, mellow fine sandy loam, stratified with slightly lighter or heavier textured material of the same character.

About 1 square mile of an included area of very fine sandy loam texture borders Middle Creek in the northern part of the area. Aside from the slight textural difference, this body of soil does not differ essentially from the typical soil.

Yolo fine sandy loam occupies an area of about 4 square miles in the Clear Lake area. It is a recent alluvial soil of mixed origin and occupies stream bottoms which are subject to periodic overflow. Aside from the area of finer-textured material already mentioned, the soil occurs principally in a comparatively large body 2 miles northwest of Lakeport. Several smaller widely separated bodies border Scott Creek to the west and northwest of Lakeport. Small areas are 1 mile east of Witter Springs, along Kelsey Creek south of Kelseyville, southwest of Kelseyville, in the vicinity of Lower Lake, along Putah Creek in the southeastern part of the area, and in the vicinity of Middletown.

The soil is well drained except during periods of unusually high water when it may be flooded for several days.

Practically all the land is under cultivation. It is valued highly for fruit production, to which fully 75 per cent of it is devoted. Pears occupy the largest acreage, and some prunes, apples, cherries, grapes, walnuts, and a variety of other fruits or nuts are grown. Alfalfa, wheat, oats, barley, and corn are the most important general farm crops.

Alfalfa is generally produced without irrigation. It is usually cut for hay twice each season, the first cutting averaging about $1\frac{1}{2}$ tons to the acre and the second 1 ton. After this the crop is allowed to mature for seed or is used for pasturage. The seed yields an average of about 200 pounds to the acre. Barley and oats yield from 15 to 22 sacks (30 to 44 bushels) and wheat somewhat less. Corn is grown both for grain and silage, and good yields are generally obtained. The general farm crops are grown largely for local sale or as feed for the farm livestock. Pear orchards on this soil are thrifty and produce well, from 15 to 20 or more tons to the acre. Other fruit and nut crops return good yields.

When sold alone areas of this soil in mature pear orchards are held at prices ranging from \$1,500 to \$2,000 an acre. Areas devoted to general farm crops can be bought for \$200 to \$300, depending on location and improvements.

Yolo fine sandy loam is a productive soil, easily handled and generally well farmed. Under general farm practices a rotation to include alfalfa, a grain crop, and a cultivated crop will maintain the soil in a highly productive state for an indefinite period. Stable manure should be applied to the orchards. For continued successful fruit production it is essential that the soils be supplied with organic matter either in the form of stable manure or by turning under cover crops. It is suggested that a leguminous crop, such as vetch, bur clover, or sweetclover, be grown as a cover crop and turned under before the stems have become fibrous or dry.

Yolo fine sandy loam, poorly drained phase.—The surface soil of Yolo fine sandy loam, poorly drained phase, to a depth ranging from 6 to 10 inches, consists of light-brown or light grayish-mellow fine sandy loam. The upper subsoil layer, which continues to a depth ranging from 24 to 36 inches, is mealy or granular light grayish-brown very fine sandy loam or silt loam. The lower part of the subsoil to a depth of 72 or more inches is dull-brown or dull grayish-brown stratified loam or clay loam, mottled with rust brown. The soil throughout is loose and friable and easily penetrated by plant roots.

This phase of Yolo fine sandy loam is inextensive. It occupies stream bottoms and is found only in the western part of the area. A body including about 1 square mile is 2 miles northwest of Lakeport, a long narrow body borders Middle Creek just west of Upper Lake, two smaller bodies occur $1\frac{1}{2}$ miles east of Witter Springs, and several small patches border Clear Lake or streams adjacent to the lake.

Surface drainage ranges from fair to good, but subdrainage is deficient, resulting in the mottled condition of the subsoil. The soil is overflowed at rare intervals.

Practically all the land of this phase is under cultivation. The same crops are grown as on typical Yolo fine sandy loam. Hops yield about 2,000 pounds to the acre.

This is a productive soil and is easily handled. The addition of stable manure or the turning under of cover crops meets the organic-matter requirement and in addition aids in handling the soil and improves its moisture-holding capacity.

YOLO GRAVELLY LOAM

The surface soil of Yolo gravelly loam to a depth of 8 or 10 inches consists of friable brown or light-brown gravelly loam. The gravel range from small to medium-sized waterworn rocks of various origins. They constitute approximately 20 per cent or more of the soil mass. The subsoil consists of loose friable brown or light-brown stratified material generally of gravelly sandy loam or gravelly sand texture. As a rule the gravel are slightly more numerous than in the surface soil, and in some areas the subsoil is extremely gravelly. Such areas are droughty and of little value for agriculture.

A number of small bodies which contain no gravel are included in mapping. Except for the absence of gravel, the soil is the same as the typical material. A small area of this kind occurs one-half mile west of Lower Lake, and other bodies are 2 miles north and 2½ miles south of Kelseyville, along Kelsey Creek 5½ miles south of Kelseyville, along Adobe Creek 3 miles north of Highland Springs, and 2 miles northeast of Upper Lake.

Two areas, one near Lower Blue Lake and the other 2½ miles east of Witter Springs, have silt loam surface soils. Here the subsoil is loam or silt loam, and the soil throughout is loose and friable and has higher water-holding capacity than the typical soil. These bodies are also included with the Yolo gravelly loam because of their small extent.

Yolo gravelly loam occupies river flood plains and alluvial fans. It is rather extensive, occupying an area of about 11½ square miles. Aside from the inclusions already mentioned, the soil occurs principally in a great number of different-sized bodies along the north shore of Clear Lake. It is especially well developed along Middle, Clover, and Adobe Creeks. A great number of smaller bodies are in the flood plain or on alluvial fans bordering Scott and Kelsey Creeks. Important areas border Putah Creek especially in the vicinity of Middletown. Other small bodies occur throughout the area, most of them bordering minor drainage ways. Yolo gravelly loam is well or excessively drained except during periods of overflow.

Less than 20 per cent of the land is under cultivation, the remainder being timbered with scattered oaks and used as grazing land during the fall, winter, and spring. Cultivated areas are used in the production of pears, prunes, walnuts, and general farm crops, together with a number of other fruit or nut crops. Crop yields are less than on Yolo fine sandy loam because of the tendency of the gravelly soil to dry out rather quickly during the summer.

A part of the land adjoining Clear Lake has high potential value for building sites or recreation purposes and is held at much higher prices than the agricultural value warrants. Other bodies not under cultivation may be bought at prices ranging from \$15 to \$25 an acre or slightly more.

The soil is best suited to deep-rooted crops. Were water available for irrigation it should prove valuable in the production of all crops suited to this region. The incorporation of organic matter will improve the moisture-holding capacity of the soil under present conditions.

YOLO LOAM, POORLY DRAINED PHASE

Yolo loam is represented in the Clear Lake area only by a poorly drained phase. The surface soil to a depth of 6 or 8 inches consists of light-brown, light grayish-brown, or light brownish-gray mellow heavy silty loam. In a few areas the texture grades somewhat toward very fine sandy loam. The subsoil to a depth of 72 or more inches is friable dull grayish-brown stratified silt loam, clay loam, or silty clay loam mottled with rust brown and some bluish drab. In some included areas the subsoil to a depth of 24 or more inches is similar to the surface soil and is not mottled. A small body, including about 10 acres $3\frac{1}{2}$ miles northwest of Lakeport, is somewhat heavier textured than the typical soil and therefore is not so easily cultivated.

Typical bodies of Yolo loam, poorly drained phase, are numerous in the western part of the area, where the soil is comparatively extensive and is agriculturally important. One of the largest bodies is on the flood plain of Middle Creek at Upper Lake. Several small bodies lie at distances ranging from one-half to $1\frac{1}{2}$ miles from this larger area. Several bodies border Scott Creek east of Lower Blue Lake and west of Lakeport.

The soil is overflowed at rare intervals, otherwise surface drainage is good or fair. Subdrainage, however, is poor.

Practically all of Yolo loam, poorly drained phase, is under cultivation to nearly all the crops suited to local conditions. Pears occupy approximately 60 per cent of the cultivated acreage. Alfalfa and hops rank next in importance, and smaller acreages are in prunes, walnuts, apples, grapes, barley, corn, and oats.

Mature pear orchards on this soil yield from 15 to 22 tons to the acre. Under good management and favorable conditions higher yields are possible. Alfalfa yields from $2\frac{1}{2}$ to 3 tons when cut for hay. The last crop is frequently left for seed and returns an average of about 200 pounds to the acre. Alfalfa furnishes considerable pasturage during the winter season. Hops and general farm crops give profitable returns.

When sold alone areas of this soil devoted to alfalfa and general farm crops are held at prices ranging from \$250 to \$350 an acre, depending on location and improvements. Land in hops is held at about \$1,000 an acre, and that in pears brings from \$1,500 to \$2,000.

Most of the land is well farmed and responds readily to good cultural practices. It seems best suited to pear production, and several young walnut groves look promising. It is suggested that more care be exercised to return organic matter to the land.

YOLO CLAY LOAM, POORLY DRAINED PHASE

Like Yolo loam, Yolo clay loam is represented in this area only by a phase in which drainage is less well developed than in the typical Yolo soils. The surface soil of Yolo clay loam, poorly

drained phase to a depth of 6 or 8 inches consists of light-brown or light grayish-brown friable clay loam. The subsoil to a depth ranging from 24 to 36 inches consists of light-brown or light grayish-brown fine sandy loam, loam, or clay loam which is generally somewhat stratified. The lower part of the subsoil, which continues to a depth of 72 or more inches, is dull grayish-brown clay loam or clay, is also stratified, and mottled with rust brown.

Included with this soil because of their small extent are several bodies of gravelly loam texture. In such areas the subsoils generally consist of gravelly loam or gravelly clay loam, and the point at which mottling appears in the subsoil is, as a rule, somewhat deeper than in the typical soil. The gravelly bodies, which occur in the flood plains of Middle Creek and Scott Creek and one-half mile north of Seigler Springs, are shown on the accompanying soil map by gravel symbols.

Typical bodies of the poorly drained phase of Yolo clay loam are 1 and 4 miles west of Upper Lake, along Clover Creek 2½ miles east of Upper Lake, and 1 mile east of Witter Springs.

Surface drainage ranges from fair to good except during periods of overflow. The subsoil is poorly drained and in most places remains saturated during the wetter months of the year.

Practically all the soil is under cultivation, mainly to pears and alfalfa. A number of other crops are grown in small acreages. The yields are similar to those obtained on the poorly drained phase of Yolo fine sandy loam, and suggestions given for the improvement and utilization of that soil are applicable to this.

COLE FINE SANDY LOAM

To a depth of 6 or 8 inches the surface soil of Cole fine sandy loam is light grayish-brown or light-brown friable fine sandy loam which is low in organic matter and generally breaks up under cultural operations into small or medium sized clods. The upper part of the subsoil to a depth ranging from 18 to 24 inches consists of light grayish-brown or light-brown slightly compact loam or sandy clay loam. This material, although compact, has considerable pore space which facilitates free movement of air and water. The lower part of the subsoil to a depth ranging from 38 to 50 inches is dark dull-brown very compact clay loam or heavy loam slightly mottled with gray and yellow. The underlying substratum, which continues to a depth of 72 or more inches, is dull-brown, dark dull-brown, or, in some places, black extremely compact sandy clay loam most of which is mottled with gray and yellow. The mottling in the subsoil and substratum is caused by incomplete subdrainage and a consequently poorly oxidized condition owing to saturation of the soil during part of the year.

Included in mapped areas of Cole fine sandy loam are three small bodies, bordering Clear Lake 2 miles north of Lakeport, which have a sandy loam texture. They consist of loose friable sandy loam to a depth ranging from 36 to 54 inches, at which depth they are underlain by gray or dark-gray clay or clay loam, slightly mottled with yellow and rust brown.

This soil is associated with other old valley-filling soils near the base of alluvial fans bordering sluggish streams or adjacent to the

flat, poorly drained soils bordering Clear Lake. It is most extensively developed in Coyote Valley in the southeastern part of the area. A small body is 1 mile north of Clearlake Highlands, and a large number of small areas occur on the alluvial fans west of Kelseyville and southeast of Lakeport.

The surface of the land is gently sloping or almost flat. Natural drainage of the surface soil is fair or good, but subdrainage is poor throughout.

Approximately 70 per cent of the land is cultivated, and the remainder is covered with native grasses and a few oaks and used as grazing land for sheep and cattle. About half the cultivated area is devoted to the production of pears and the remainder to general farm crops. Some prunes are produced, but yields are not so satisfactory as of pears.

When sold alone the land in producing pear orchards is held at prices ranging from \$900 to \$1,500 an acre, depending on the age and thriftiness of the trees. General farming land brings from \$125 to \$200 an acre, depending on location and improvements.

Cole fine sandy loam is well suited to pear production and under future development can be utilized to greater extent for this purpose. The soil should be supplied with organic matter either by applying stable manure or by turning under cover crops.

Cole fine sandy loam, gravelly phase.—The surface soil of the gravelly phase of Cole fine sandy loam consists of 6 or 8 inches of light-brown or light grayish-brown gravelly fine sandy loam. The subsoil to a depth of 45 or 50 inches is compact grayish-brown or light-brown gravelly loam or clay loam. The substratum to a depth of 72 or more inches consists of dull-brown or dull grayish-brown gravelly clay loam mottled with rust brown or yellow.

This soil, which is inextensive, is associated with other soils of the Cole series, lying near the poorly-drained soils adjacent to Clear Lake. Two small bodies are 2 miles north of Lakeport, 2 lie at distances of $1\frac{1}{2}$ and 4 miles west of Kelseyville, 2 very small areas are northeast of the above-mentioned bodies, and 1 small body occupies a slight knoll three-fourths mile northeast of Kelseyville.

Surface drainage is fair or good, but a high water table during the rainy season interferes with subdrainage.

Practically all the land is under cultivation and is used largely in the production of pears. However, orchards present a somewhat spotted growth.

The chief need of this soil is subdrainage, which could be partly effected by lowering the water level of Clear Lake.

Cole fine sandy loam, heavy-textured phase.—The surface soil of Cole fine sandy loam, heavy-textured phase, is dull grayish-brown or dark brownish-gray friable fine sandy loam to a depth of 5 or 7 inches. The subsoil, which continues to a depth ranging from 40 to 50 inches, is dull-gray or dark-gray tight compact fine sandy loam or clay loam. The substratum to a depth of 72 or more inches is dark-gray or grayish-drab tight compact sandy clay or clay loam which is in most places somewhat mottled with gray, yellow, or rust brown.

Soil of this phase is inextensive. A number of small bodies are adjacent to Clear Lake or to stream courses debouching on the

alluvial fans west of Kelseyville. Several small areas occur north of Lakeport bordering the lake, one is south of the lake, and several are west of Kelseyville.

The smooth surface is gently sloping or almost flat. Only a few shallow drainage ways traverse the areas. Surface drainage is well developed, but subdrainage is poor.

About 80 per cent of the land is under cultivation largely to pears. Some prunes and general farm crops are produced. Uncultivated areas are covered with grass and scattered oaks and are valued for grazing. Areas close to Clear Lake are in demand for building sites.

Crop yields are the same or slightly higher than on typical Cole fine sandy loam. Suggestions for the improvement and utilization of the typical soil and the phase are the same.

Cole fine sandy loam, calcareous-subsoil phase.—The surface soil of Cole fine sandy loam, calcareous-subsoil phase, consists of 5 or 7 inches of light-brown or brown friable fine sandy loam which works up under cultivation into a mellow granular or small cloddy structure. The upper subsoil layer to a depth ranging from 18 to 24 inches consists of light-brown or brown slightly compact fine sandy loam or loam which changes abruptly to dark-gray, dull grayish-brown, or, in some places, black clay loam or clay mottled with rust brown or yellow. This material is compact and continues uniform to a depth ranging from 38 to 45 inches, at which depth it is underlain to a depth of 72 or more inches by light brownish-gray or grayish-brown calcareous granular clay loam mottled with yellow and rust brown.

Soil of this phase is not extensive. Areas border the poorly drained calcareous soils adjacent to Clear Lake. Several bodies are south and southeast of Lakeport, 1 small body is 1½ miles north of Lakeport, 1 occurs one-half mile north of Lower Lake, and 2 border Cold Creek 2 miles north of Kelseyville.

Surface drainage ranges from fair to good, but subdrainage is poor owing to the presence of a high water table during part of the year when the water in Clear Lake rises to a high level.

The soil is used almost exclusively in the production of pears which yield well, but, owing to the calcareous subsoil, orchards planted on the Japanese root show a rather spotted growth in some places. The French root seems best adapted to this soil. A few small bodies are devoted to barley and oat production, and good yields are obtained.

COLE CLAY LOAM

The surface soil of Cole clay loam to a depth of 4 or 6 inches consists of dull brownish-gray or dark dull-brown clay loam which breaks up under cultivation into a coarse cloddy mass. The upper subsoil layer to a depth ranging from 18 to 24 inches is dark-gray or dark brownish-gray compact clay loam. This material changes gradually to dull brownish-gray or dull grayish-brown material which is slightly less compact and mottled with yellow and rust brown. The lower subsoil layer continues to a depth ranging from 48 to 60 inches, and it is underlain by a substratum of dark-gray or dark brownish-gray clay mottled with rust brown. The substratum is uniform in structure to a depth of 6 or more feet.

Cole clay loam occurs in a great number of small bodies throughout the area. The areas border stream courses of sluggish drainage, or they occur just above the black poorly drained soils adjacent to Clear Lake. A fairly large area is at Upper Lake, and a small body is 2 miles south of that place. A number of bodies lie about one-half mile south of Clear Lake between Lakeport and Soda Bay; others occur on the alluvial fans west of Kelseyville, 6 miles east of Middletown, and just east of Seigler Springs.

The surface is smooth and gently sloping, affording fair or good surface drainage. Subdrainage, however, is poor owing to a high water table during the rainy season.

Approximately 70 per cent of the land is under cultivation, principally to pears. About 40 per cent of the cultivated acreage is used for general farm crops.

Although Cole clay loam is valued for pear production the orchards present a somewhat more spotted appearance than on the better-drained Rincon soils.

Care should be exercised in handling this soil in order to prevent puddling, which results if the land is worked when too wet. Breaking up the hard plow pan or plow sole prevalent over much of this soil would result in better aeration of the soil and facilitate water movement through it.

RINCON LOAM

Rincon loam to a depth of 6 or 8 inches is brown or dull-brown friable fine sandy loam or loam which works up to a granular or medium cloddy structure under cultivation. The surface soil grades into brown or dull-brown moderately compact fine sandy loam which is readily permeable to air, moisture, and plant roots. This material continues to a depth ranging from 20 to 30 inches and is underlain by tight compact brown or dull-brown clay loam or heavy loam which continues to a depth between 60 and 72 inches. This layer is less permeable to moisture or plant roots than the layers above, and it contains few root cavities. The substratum is lighter in texture, in a few places gravelly, and it is less compact than the overlying subsoil layer. The material has weathered but slightly and in this respect more nearly resembles the surface soil.

Rincon loam is developed from an old valley-filling deposit of mixed origin. It occupies alluvial terraces or fan slopes several feet above the present stream flood plains. Surface drainage and subdrainage are well developed. Drainage ways traversing the areas occupy shallow depressions, and erosion is not active.

Rincon loam areas of various sizes are distributed throughout the Clear Lake area, predominantly and more typically on the alluvial fans in the vicinity of and west of Kelseyville. Several bodies are in the vicinity of Lower Lake and bordering the larger streams south of that place, a number of small areas border Putah Creek in Coyote Valley and north and south of Middletown, and other small bodies are widely distributed throughout the area.

Rincon loam is one of the most important soils of the area, both in area and utilization. It is a productive soil and easily cultivated. Probably 80 per cent of the land is under cultivation, and the remainder is covered with white and black oaks or pines. Pears, for

which the area is noted, are the principal crop grown. (Pl. 1, A.) Some prunes, apples, peaches, and general farm crops, including wheat, oats, barley, corn, and alfalfa, are successfully grown. Some walnut and almond groves produce good yields and offer opportunity for future development. Well-improved pear orchards are held at prices ranging from \$900 to \$1,200 or more an acre. Areas devoted to general farming purposes bring from \$100 to \$200, depending on location and accessibility to market.

Rincon loam is generally well farmed, and the orchards are well cared for. In many places, however, continued shallow plowing or disking has resulted in the formation of a hard compact layer or plow sole at a depth ranging from 4 to 6 inches. This condition should be corrected, and free circulation of air and moisture through the soil would result if the plow sole were broken up. Moisture conditions during the spring months are generally unfavorable to early cultural practices. It is recommended that when possible the cover crops grown on the soil be plowed under before the growth has become tough and fibrous. In many orchards undecayed fibrous vegetable growth is found in the soil throughout the summer. It is also believed that where water can be obtained at a depth ranging from 40 to 60 feet, irrigation of the orchards about 30 days before the pears are ready to pick will result in better-sized fruit and prevent much dropping of unripened fruit.

RINCON GRAVELLY SANDY LOAM

Rincon gravelly sandy loam, to a depth of 8 or 10 inches, is characterized by a brown or light-brown friable gravelly sandy loam surface soil. The gravel are of medium size, well rounded, and constitute about 15 or 20 per cent of the soil mass. The upper subsoil layer, to a depth ranging from 40 to 50 inches, is brown or dark-brown moderately compact gravelly sandy loam or loam. This material is underlain by brown or light-brown compact dense gravelly fine sandy loam or loam which continues to depths between 65 and 75 inches. The substratum is lighter in texture and less compact than the material above and is very similar in color and texture to the surface soil. The gravel in the subsoil are similar to those in the surface soil and compose about the same proportion of the soil mass.

As mapped the soil includes two small bodies which are underlain by a volcanic tuffaceous rock at a depth ranging from 36 to 50 inches. In these bodies, which lie $2\frac{1}{2}$ and $3\frac{1}{2}$ miles south of Konokti Bay, the surface soil and subsoil are similar to the typical soil and subsoil, but, owing to the imperviousness of the lower subsoil layer, their agricultural value is restricted.

Rincon gravelly sandy loam occupies an area of about 7 square miles. It is associated with other old valley-filling soils and most of the areas border stream courses or occupy alluvial fans throughout the area. An area including about 1 square mile is 2 miles north of Clearlake Highlands, a number of small bodies occur on the alluvial fans in the vicinity of and west and south of Kelseyville, a large body borders the poorly drained soils in High Valley 2 miles north of Clear Lake Oaks, and numerous other areas are near Middletown.

The relief is terracelike or fanlike. The gently sloping surface is little marked by erosion. Surface drainage and subdrainage under natural conditions are well developed.

Approximately 80 per cent of the land is under cultivation, and the remainder is timbered with a scattered growth of oaks and is used as grazing land. Wheat, barley, and oats occupy 60 or more per cent of the cultivated acreage, and the remainder is devoted largely to pear, prune, and grape production. Average yields are lower than on Rincon loam.

When sold alone the soil is valued somewhat lower than the non-gravelly soils of the Rincon series.

Under general-farming practices, some stable manure is applied to the soil. The more complete utilization of stable manure or the turning under of cover crops is advisable in order to increase the organic-matter supply and the water-holding capacity of the soil. Where water is available at a reasonable depth, irrigation should prove profitable in the production of fruit and nut crops.

Rincon gravelly sandy loam, reddish-brown phase.—The surface soil of the reddish-brown phase of Rincon gravelly sandy loam consists of reddish-brown or rich-brown friable gravelly sandy loam to a depth ranging from 6 to 10 inches. In uncultivated areas the soil bakes badly on drying on account of the low organic-matter content. Under cultivation a hard compact layer or plow sole, caused by continued shallow plowing, is developed over much of the soil. The upper subsoil layer is compact reddish-brown gravelly loam or clay loam to a depth ranging from 36 to 45 inches. The lower part of the subsoil to a depth of 65 or 70 inches consists of reddish-brown or brownish-red dense compact gravelly clay loam or gravelly loam. The gravel in the subsoil are coated to more or less extent with reddish-brown colloidal material. The substratum is less compact than the subsoil and is stratified, the different strata consisting of gravelly loam or gravelly sandy loam. The gravel throughout the soil are of medium size, are well rounded or subangular, and they occupy from 15 to 20 or more per cent of the soil mass.

Soil of this phase occurs only in the eastern and southeastern parts of the area. It occupies alluvial fans and terraces adjacent to drainage ways or to Clear Lake. Several bodies are from 1 to 5 miles north of Clearlake Highlands. The largest bodies border Putah Creek and its tributaries in the southeastern part of the area.

The surface is smooth, cut only by a few shallow drainage ways or gullies, and erosion is slight. The soil is naturally well drained, and some of the more gravelly areas are excessively drained.

About 50 per cent of the land is under cultivation, and the remainder, which is covered with a scattered growth of oaks, is used as grazing land. About 50 per cent of the cultivated area is used in the production of general farm crops including barley, oats, and wheat, the rest being used in the production of prunes, grapes, pears, and some walnuts and almonds. Grain yields are about the same as on typical Rincon gravelly sandy loam, but fruits and nuts produce somewhat less.

The soil is productive, but crops suffer from lack of moisture sooner on this than on the nongravelly Rincon soils. Were water available for irrigation, the soil would be well adapted to all fruit

or nut crops grown in this locality. It should be well supplied with organic matter to facilitate cultivation and to increase the fertility and water-holding capacity.

RINCON VERY FINE SANDY LOAM

In virgin areas, the surface soil of Rincon very fine sandy loam to a depth of $1\frac{1}{2}$ or $2\frac{1}{2}$ inches, perhaps slightly more, consists of loose granular light grayish-brown or light-brown very fine sandy loam. Directly beneath the surface layer and continuing to a depth ranging from 8 to 12 inches the soil is light-brown or light grayish-brown fine sandy loam or very fine sandy loam which is firm when dry but granular and friable when wet. The material contains an appreciable amount of pore space through which air and water may circulate freely. The upper subsoil layer, to a depth ranging from 24 to 34 inches, consists of light-brown or rather dull-brown moderately compact fine sandy loam, loam, or clay loam which also has appreciable pore space, affording free circulation of air and water. The lower subsoil layer to a depth ranging from 60 to 70 inches is more dense and compact and consists of light-brown or dull-brown loam or clay loam tinted with yellow. The subsoil on drying cracks into coarse clods or columns, and along the partings there is generally a thin coating of colloidal material which has been deposited by waters moving downward from the surface soil. The substratum to a depth of 90 or more inches is light-brown or light grayish-brown dense compact loam or heavy fine sandy loam.

Some areas in which the subsoil or substratum is slightly mottled, owing to poor subdrainage, are included with Rincon very fine sandy loam in mapping. Such areas closely resemble the typical soil and are of equal agricultural value.

This is not an extensive soil. Its largest development is in the eastern part of the area $1\frac{1}{2}$ miles east and 1 mile south of Lower Lake. A small area is in the south-central part, 4 miles south of Kelseyville.

The soil is naturally well drained, as it occupies alluvial fans and stream terraces several feet above the present stream flood plain. About 80 per cent of the land is under cultivation and is used in the production of general farm crops, fruits, and nuts. Wheat, oats, and barley occupy most of the cultivated acreage, and some corn, alfalfa, pears, and prunes are grown.

The soil is given no fertilizer treatment other than the available supply of stable manure. The practice of crop rotation is advisable, and the turning under of a cover crop or other organic matter to maintain fertility would prove profitable.

CLEAR LAKE CLAY ADOBE

Clear Lake clay adobe is characterized by a surface soil from 5 to 8 inches deep of dark-gray or black clay, which on drying checks into large blocks giving the material what is commonly known as an adobe structure. (Pl. 1, B.) The blocks subdivide into small cubical and irregular fragments. The upper subsoil layer to a depth ranging from 12 to 24 inches is dark-gray or black moderately compact tight clay which on drying cracks into columns from 6

to 8 inches in diameter. The lower subsoil layer to a depth of 72 or more inches is somewhat less dark gray calcareous clay stratified to some extent with dark-colored materials of various textures. Some rust-brown mottles are present in this layer. The lime is evenly distributed through the subsoil without any tendency toward accumulation.

Clear Lake clay adobe is one of the more extensive soils of the Clear Lake area. Nearly 9 square miles of the soil are mapped, most of which adjoins Clear Lake. The largest bodies are in the vicinity of Lakeport and extending east of that place nearly as far as Soda Bay. Smaller areas are along the eastern shore of the lake, particularly in the vicinity of Clear Lake Oaks, Lower Lake, and Clearlake Highlands, and many other bodies, most of them small, lie along the western shore. A number of large areas border Putah Creek and its branches in the southeastern part of the area. Important bodies lie 1 and 3 miles northeast of Middletown and in the vicinity of McCurry Lake.

The land is flat, and drainage is poorly developed, allowing water to stand over the surface for long periods during the rainy season.

About 30 per cent of the land is under cultivation, and the remainder is carpeted with grass or sedges which afford good grazing. The cultivated areas are used almost exclusively in the production of pears, to which purpose the better-drained areas seem well suited. Care must be exercised to cultivate this soil under optimum moisture conditions, as when plowed while wet it puddles badly.

Clear Lake clay adobe, upland phase.—The surface soil of the upland phase of Clear Lake clay adobe, to a depth of 7 or 9 inches, consists of adobe-structured dark-gray or black clay. The upper subsoil layer, to a depth ranging from 36 to 48 inches, consists of dark-gray or black clay which cracks badly on drying. The lower subsoil layer is dark-gray calcareous clay to a depth of 72 or more inches.

Soil of this phase occurs on elevated benches, hill slopes, or fan slopes in the southwestern and southeastern parts of the area. The largest bodies are 4 miles south of Kelseyville and one-half mile west of McCurry Lake. Three small bodies border Putah Creek 3 miles north of Middletown.

Surface drainage ranges from fair to good, but subdrainage is poor owing to the tightness and imperviousness of the subsoil. The soil is subject to considerable seepage from higher-lying areas.

Less than 10 per cent of the land is under cultivation. The uncultivated areas are used as grazing land.

The soil is best adapted to general farm crops, though in seasons of low rainfall crops suffer from lack of moisture more quickly than on lighter-textured soils.

DUBLIN CLAY ADOBE

The surface soil of Dublin clay adobe to a depth of 8 or 10 inches consists of dark-gray or black clay of adobe structure. The surface soil is mottled here and there with rust brown. The subsoil to a depth of 72 or more inches consists of dark-gray or black slightly compact clay mottled with rust brown.

As mapped the soil includes several bodies of lighter and of gravelly texture, which are shown on the soil map by gravel symbols. The upper subsoil layer also is of lighter texture. It is friable, gravelly, and of a dark-gray color to a depth ranging from 30 to 40 inches. The lower subsoil layer consists of dark-gray or black gravelly clay loam or clay. Gravelly areas lie one-fourth mile east and 2 miles northeast of Upper Lake, and several small gravelly bodies occur at widely separated points along the north shore of Clear Lake. Two small areas of fine sandy loam texture are also included. In these areas the subsoil to a depth of 36 or 40 inches is dark-gray fine sandy loam or loam which is underlain by moderately compact dark-gray or black clay loam or clay. One such area borders Clear Lake 1 mile north of Lakeport, and the other is 2 miles southeast of Upper Lake.

Bodies of the typical soil occur in a number of places throughout the area. The most typical development is in four comparatively large bodies lying 2 and 3 miles west and northwest, and one-half mile north of Kelseyville. Small areas occur $1\frac{1}{2}$ miles south and 3 miles west of that place, several small bodies border Clear Lake north of Lakeport, and others are $3\frac{1}{2}$ miles southeast and 3 miles west of Upper Lake. An area occupying what was once a lake bed lies just north of Howard Springs.

Dublin clay adobe areas are flat, affording incomplete drainage to surface soils and subsoils. The water table is high during the greater part of the year, and during the rainy season water frequently stands over the surface of the ground for several days at a time.

This is not an important agricultural soil. About 25 per cent of it is under cultivation, largely for pear production. Virgin areas are covered with grasses and water-loving sedges and are used for grazing. Pear orchards generally have a spotted appearance. The crop yields are similar to those obtained on Clear Lake clay adobe.

The chief requirement of Dublin clay adobe is drainage, and this can not be effected in most places because of lack of a suitable outlet.

MANZANITA CLAY LOAM

Under virgin conditions the surface soil of Manzanita clay loam to a depth of 1 or 2 inches consists of brown, pale reddish-brown, or yellowish-brown granular, friable clay loam containing many grass roots and a few small spherical iron concretions or shotlike pellets. To a depth of 6 or 8 inches the surface soil is pale reddish-brown, pale brownish-red, or somewhat yellow clay loam of firm consistence. This horizon contains much pore space, and on plowing or when disturbed the material breaks up readily to a small granular structure. Numerous iron pellets occur in this horizon. The subsoil consists of an upper zone, which extends to a depth ranging from 22 to 28 inches, of pronounced reddish-brown or brownish-red moderately compact heavy clay loam or clay with a moderate amount of pore space. The material breaks up to a medium granular structure as soon as disturbed. Iron concretions or pellets are numerous in this layer also. The next layer to a depth ranging from 28 to 40 inches is red or brownish-red very compact clay loam or clay containing numerous embedded partly weathered gravel. When disturbed the material in this layer breaks into coarse clods. The

lower subsoil layer to a depth ranging from 65 to 75 inches consists of pale-red or yellowish-red dense extremely compact clay loam or clay containing a great quantity of well-weathered gravel which may be readily cut with a shovel or soil hammer. The weathered gravel when broken gives this layer a somewhat mottled red, yellow, and gray appearance. The substratum extending from 90 inches to undetermined depths consists of pale-red or pale yellowish-red very compact dense clay loam containing numerous well-weathered gravel.

As mapped the soil includes some bodies, lying north of Lower Lake and east of Middletown, which have a shallower surface soil overlying the compact clay or clay loam subsoil. In such areas the subsoil may be reached at a depth ranging from 18 to 24 inches or even at a slighter depth. They have a lower agricultural value than the typical soil.

Manzanita clay loam is derived from an old, well-weathered terrace deposit of mixed origin. Drainage ways have dissected the land until it has almost lost its terrace form in many places, leaving the surface undulating or gently rolling with a few flat-topped ridges. Drainage is well developed.

The soil extensively developed on the benches adjacent to Clear Lake. Typical bodies occur just west of Lakeport, in a number of places west and southwest of Kelseyville, and north of Highland Springs. Several large areas border the eastern end of Clear Lake from 3 to 5 miles north of Lower Lake, and a number of bodies are south and west of Middletown.

Manzanita clay loam is a productive soil, and it is utilized in the production of nearly all crops grown in this region. Under virgin conditions it is covered with manzanita and other brushy shrubs and oaks, together with some pines. About 25 per cent of the land is under cultivation, and grapes, peaches, walnuts, prunes, and pears, together with a variety of small fruits, are produced successfully. Wheat, oats, and barley also give satisfactory returns in favorable seasons.

Well-improved areas of this soil in orchards are held at prices ranging from \$700 to \$1,000 or more an acre. Uncleared areas bring from \$10 to \$25 an acre.

It is essential that this soil be supplied with organic matter from year to year in order to improve its moisture-holding capacity and to maintain its fertility. The tendency to form a plow sole is prevalent over much of the land, and this should be avoided by plowing at different depths from year to year. It is believed the soil will prove well adapted to walnut culture under future development.

MANZANITA GRAVELLY FINE SANDY LOAM

The surface soil of Manzanita gravelly fine sandy loam to a depth of 6 or 8 inches consists of pale reddish-brown or light brownish-red gravelly fine sandy loam. The gravel are rounded waterworn rock fragments, predominantly quartzite, generally from 1 to 2 inches in diameter. Under cultivation the surface soil is loose and friable, but it becomes hard and bakes if left bare after cultivation. The subsoil includes an upper layer of pale brownish-red or dull-red moderately compact gravelly fine sandy loam underlain by a lower subsoil layer, extending from a depth ranging from 18 to 24 inches

to a depth of 50 or 60 inches, of brownish-red or red extremely compact dense gravelly clay loam. The gravel in this layer are well weathered and can be readily cut with a soil hammer or shovel. The substratum, which continues to an undetermined depth, is less compact pale-red or pale yellowish-red gravelly clay loam or heavy loam. The gravel in this material are also well weathered.

Manzanita gravelly fine sandy loam is weathered in place from a very old valley-filling deposit. The soil occupies old alluvial terraces which are at present cut by numerous drainage ways, giving the areas an undulating or gently rolling relief with a few flat-topped terrace forms. Both surface soil and subsoil are well drained.

The soil is most extensively developed 2 miles southwest of Kelseyville. Several small areas occur near the headwaters of Kelsey Creek, and others border Cold Creek south of Kelseyville.

The native vegetation consists largely of manzanita, Ceanothus, and other low-growing brush, together with a few oaks and pines. About 15 per cent of the land is cleared and used in the production of prunes, walnuts, grapes, peaches, apples, pears, and other fruits, as well as general farm crops. The yields obtained are somewhat lower than on Manzanita clay loam.

Well-improved areas are held at prices ranging from \$500 to \$800 or more an acre. Areas still in brush bring from \$5 to \$20 an acre.

Manzanita gravelly fine sandy loam can be improved, both in moisture-holding capacity and fertility, by plowing under cover crops or by the addition of barnyard manure.

PINOLE LOAM

The surface layer of Pinole loam to a depth of 1½ or 2 inches consists of light grayish-brown or light yellowish-brown granular fine sandy loam containing a few small iron-cemented pellets or concretions. This is underlain by a subsurface layer, which continues to a depth of 6 or 8 inches, consisting of light yellowish-brown firm fine sandy loam which when disturbed breaks down readily to a small-granular structure. The surface soil contains a great number of cavities left after the decay of plant roots. The upper subsoil layer to a depth ranging from 10 to 15 inches is slightly compact light yellowish-brown fine sandy loam or loam, which breaks into medium-sized clods, and these clods are readily broken up into a granular mass. This layer contains less root cavities than the overlying soil. The lower subsoil layer to a depth ranging from 20 to 26 inches is characterized by very compact dense light yellowish-brown heavy loam or clay loam which contains an appreciable quantity of well-weathered gravel coated with dull-brown or dull yellowish-brown colloids. The gravel may be chopped through very readily with a spade or soil hammer. The material below this and continuing to depths between 60 and 70 inches is light reddish-brown or dull yellowish-brown dense very compact gravelly clay loam or heavy loam which breaks into large clods. Owing to the imperfect weathering or oxidization of the gravel, the soil in this layer shows a yellow, red, and gray mottling. The parent material, or substratum, which extends to an undetermined depth, is light yellowish-brown or grayish-brown material contain-

ing numerous well-weathered gravel. The material of the substratum is amorphous, but it breaks up to a small cloddy structure.

Pinole loam is developed on an old alluvial deposit of mixed origin. It occupies elevated terraces which are dissected by numerous drainage ways affording good regional drainage. The land ranges from undulating to rolling, and is marked by many flat-topped ridges and a few gently sloping fanlike areas.

This is one of the more extensive soils of the area. Typical bodies are at Lakeport and on the benches north and west of that place. Large bodies border the rough mountainous land extending south from Lakeport a distance of several miles, and a number of small areas are south of Kelseyville and north and south of Lower Lake. The soil borders the alluvial soils adjacent to Putah Creek west and south of Middletown.

A scattered growth of oak trees or a dense growth of brush covers the soil under virgin conditions. About 10 per cent of the land is under cultivation and used in the production of a variety of fruits and general farm crops. Uncultivated areas covered with oaks are used as pasture land for sheep and cattle.

Well-improved land of this kind is held at prices ranging from \$400 to \$800 an acre, depending on improvements and accessibility to market. Unimproved areas bring from \$8 to \$20, except some bodies lying near Clear Lake which are valued as building sites and command higher prices.

Pinole loam is not valued so highly as the associated Manzanita soils. However, most of it responds to the application of barnyard manure or the turning under of cover crops. The soil seems best suited to grapes, peaches, and prunes.

Pinole loam, gray phase.—The gray phase of Pinole loam is characterized by an 8 or 10 inch dull brownish-gray or dull-gray loam surface soil which is compact and firm except where cultivated. The upper subsoil layer to a depth of 16 or 20 inches is dull-gray moderately compact heavy fine sandy loam or loam containing considerable pore space left by the decay of plant roots. The lower subsoil layer consists of compact heavy gravelly loam or clay loam to a depth of 36 or 40 inches, at which depth the material becomes increasingly compact and dense. A great quantity of well-weathered gravel, which are coated with colloidal material and which can be crushed readily under slight pressure, are present in this layer. The substratum is firm dense gravelly clay loam or clay in which some rust-brown mottling is apparent, owing to the incomplete oxidization of the iron contained in the weathering gravel.

Soil of the gray phase is associated with typical Pinole loam. It has developed under poor drainage. At present, however, most of the land is well drained, though in some areas underdrainage is restricted and other areas receive seepage water from the higher terraces.

A number of small bodies of this soil occur in the vicinity of Lakeport, bordering the lowlands adjacent to Clear Lake, and a small area is 3 miles south of Kelseyville.

About 5 per cent of the land is under cultivation, and the remainder is covered with oaks or brush. Prunes and pears are the principal crops grown, and the yields are somewhat lower than on the typical

soil. The soil is sold in conjunction with Pinole loam, but its value is lower.

Suggestions for the improvement and utilization of the phase are the same as for the typical soil.

PINOLE GRAVELLY FINE SANDY LOAM

Pinole gravelly fine sandy loam is characterized by a surface soil from 5 to 7 inches deep of light-brown or light yellowish-brown gravelly fine sandy loam which is of firm structure until disturbed, when it works up to a granular mass. The upper subsoil layer to a depth ranging from 20 to 30 inches consists of yellowish-brown firm compact gravelly fine sandy loam having a shade of pink. This material contains a moderate amount of pore space caused either by the decay of plant roots or by the action of burrowing animals. The lower subsoil layer to a depth ranging from 45 to 60 inches is dull-brown, dark reddish-brown, or yellowish-brown very compact dense gravelly clay loam or heavy loam. The gravel in this layer are coated to greater or less extent with a dull-brown colloidal deposition. They are well weathered and can be readily cut through with a shovel or soil hammer. The substratum, which extends beyond a depth of 70 inches to an undetermined depth, is dull grayish-brown or brownish-gray gravelly loam or clay loam which is less compact and dense than the layer above. Silts, clays, and colloidal material weathered from the surface soils have not penetrated the material to a great extent, though weathering has caused the gravel to become soft and easily crumbled.

Included with Pinole gravelly fine sandy loam in mapping is an area at the mouth of Scott Creek. Here the surface soil is loose and permeable and the upper subsoil layer to a depth ranging from 36 to 45 inches is also loose and permeable, but in other respects the soil is similar to the typical soil. This included body is better suited to agriculture and is valued somewhat higher than typical areas.

Pinole gravelly fine sandy loam is developed on an old alluvial deposit of mixed origin which now occupies terraces lying from 50 to 100 or more feet above the present stream flood plains. The banks along drainage ways are gently sloping or well rounded, affording a rolling or slightly hilly relief with numerous flat-topped ridges or mesas.

A number of small bodies of this soil border Clear Lake north of Lakeport. It is most extensive, however, on the terraces south and southwest of Kelseyville.

About 30 per cent of the land has been cleared of brush and oaks which cover the soil under virgin conditions. The cultivated areas are planted to walnuts, prunes, grapes, and a variety of other fruits. Some oats and wheat are produced. Prunes and grapes seem best suited to the soil, but yields are somewhat lower than on Pinole loam.

When sold alone, areas of Pinole gravelly fine sandy loam in mature orchards or vineyards are held at prices ranging from \$400 to \$800 an acre depending on improvements and accessibility to market. Unimproved areas may be bought for less.

Suggestions given for the improvement and utilization of Pinole loam are applicable to this soil.

KONOKTI GRAVELLY CLAY LOAM

The surface soil of Konokti gravelly clay loam to a depth of 5 or 7 inches consists of rather dull reddish-brown or light reddish-brown granular gravelly clay loam. It contains a great number of small shotlike iron concretions or pellets. The gravel in this soil, most of which are from 1 to 2 inches in diameter, are angular chips of the parent rock. The subsoil is composed of two or more layers, the upper one to a depth ranging from 18 to 24 inches being characterized by light reddish-brown gravelly clay loam or clay of slightly cloddy structure. This layer contains fewer pellets than the surface layer and is slightly more compact. The second layer, which continues to a depth ranging from 30 to 40 inches, is light reddish-brown or pale reddish-brown compact gravelly clay loam or clay, containing few or no pellets. The lower subsoil layer, which rests on bedrock at a depth ranging from 40 to 52 inches, consists of pale brownish-red or reddish-brown friable gravelly clay loam or clay.

Many areas of Konokti gravelly clay loam as mapped in the Clear Lake area differ in color from typical Konokti soils. The soil is derived in part from weathered material having its source in andesitic rock, and in such areas a pale reddish-brown color has developed; the color grades in some areas to pale brown with a pinkish-gray tint. These variations could not be differentiated on the map owing to their occurrence in small intimately associated bodies, to their gradual transition from one color to another, and to the rough character of the areas, many of which are covered with a dense brush growth.

Konokti gravelly clay loam is associated with other soils of the area which have weathered from consolidated rocks and border the outer margins of the area. The soil is most typically and extensively developed in the vicinity of and north and west of Salminas Resort. Typical bodies occur on Mount Konokti, and a number of widely scattered areas lie near the base of the mountain. A few areas which contain few or no gravel are west and northwest of Lakeport, and a number of small bodies occur north of Lower Lake and in the vicinity of Middletown.

The relief is prevailingly hilly; a few areas are undulating or mountainous. Streams rainify all areas of this soil, affording good surface and subsoil drainage.

Under virgin conditions the land is largely timbered with pines and oaks. Some areas, however, are covered with a dense growth of *Ceanothus* and other low-growing brush. About 5 per cent of the land is under cultivation. A few producing walnut groves growing on the soil give promise of good returns, and in recent years a number of new plantings have been made. Prunes and a number of other fruits give profitable yields. Wheat and barley are grown to some extent and in favorable seasons give fair returns.

Konokti gravelly clay loam brings from \$5 to \$20 an acre where undeveloped. Improved areas in walnut groves are held at \$1,000 or more an acre, and land in prune or other orchards is held at a somewhat lower price.

This is a productive soil, though it is somewhat spotted in a few places, owing to the slight thickness of the soil material covering

the bedrock. Under good management the soil can be maintained in a productive state for an indefinite period. The deeper areas seem especially well suited to nut culture.

Konokti gravelly clay loam, stony phase.—The stony phase of Konokti gravelly clay loam consists of brown, pale-brown, or light reddish-brown stony gravelly clay loam from 5 to 10 inches thick. The upper subsoil layer to a depth ranging from 15 to 20 inches is brown, pale-brown, or light reddish-brown moderately compact stony gravelly clay loam. The deeper part of the subsoil is of about the same color as or slightly redder than the surface soil, but it is compact and of a heavy gravelly stony clay loam or light clay texture. Bedrock, consisting of andesite, obsidian, or volcanic basic tuff, lies at a depth ranging from 30 to 36 inches.

Only three bodies of this stony soil are mapped. One is 1 mile north of Lower Lake and is not developed for agricultural purposes, but is subdivided for residential or resort purposes. A larger body lies 2 miles north of Seigler Springs, and a small body occurs near Sulphur Banks on Clear Lake.

The surface is rolling, hilly, or mountainous, and drainage ranges from good to excessive.

Under virgin conditions, this stony soil is largely covered with such a dense brush growth that the soil is valueless even for grazing purposes. Some bodies are grass covered and are used during the rainy season for grazing. Less than 1 per cent of the land is cleared, and this has been set out to fruits and nuts.

Owing to the shallowness of the soil and the difficulty of clearing and removing the stones from the land, the soil has little agricultural value. In many places it very closely resembles rough stony land. It will probably never warrant the trouble and expense of clearing except in a few areas.

HUGO CLAY LOAM

The surface soil of Hugo clay loam, to a depth ranging from 4 to 7 inches, consists of rather dull-brown, light grayish-brown, or light yellowish-brown clay loam containing an appreciable quantity of very fine sand and fine sand. Plowed fields when dry generally have a decided grayish or yellowish cast. The soil is low in organic matter and in most places becomes hard and baked on drying. The upper subsoil layer to a depth between 12 and 16 inches consists of dull grayish-brown, light grayish-brown, or yellowish-brown moderately compact heavy clay loam or clay of small cloddy structure. The lower part of the subsoil is clay loam or clay of dull reddish-brown or, here and there, a yellowish-brown cast. The material is very compact and when dry shows an imperfectly developed jointed or columnar structure. At a depth ranging from 20 to 30 inches the material of this layer changes abruptly to less compact friable dull-brown, pale reddish-brown, or yellow clay loam or clay which is more or less mottled with gray and yellow, owing to the presence of partly decayed rock on which the soil rests at an average depth of about 36 inches.

Hugo clay loam has weathered in place from shale or sandstone rock. Most of the rocks are fine textured, but here and there coarse-textured areas closely resemble soils derived from igneous andesitic rocks.

Hugo clay loam occurs in the foothills and mountains in a number of places throughout the area. Some of the largest bodies are northwest of Lakeport and southeast of Upper Lake. A number of small scattered bodies border the alluvial lands adjacent to Putah Creek. The soil is also extensive along Middle Creek and north of Upper Lake. A large body is at Highland Springs, and numerous bodies occur at Lower Lake and at various other places in the area.

Areas of this soil are dissected by numerous drainage ways which afford good drainage. Most of the drainage ways are of gentle gradient, lying between gently rolling ridges or low rounded hills.

Under virgin conditions the soil is carpeted with grass, and white, black, and valley oaks dot the hillsides. A few areas are covered with a dense brush growth and are consequently of little value for grazing.

Less than 5 per cent of the land is under cultivation. Grapes and pears are the principal fruits, and wheat and barley are grown in connection with the livestock industry or with general farming operations. Crop yields are somewhat low, owing to the poor moisture-holding capacity of the soil.

Hugo clay loam, shallow phase.—The surface soil of the shallow phase of Hugo clay loam consists of a 4 to 6 inch layer of rather dull-brown, light-brown, or light grayish-brown clay loam tinged with yellow. The subsoil consists of two layers, an upper one, extending to a depth ranging from 12 to 18 inches, which is light-brown or dull grayish-brown moderately compact clay loam or clay, and a lower one of dull-brown or brown compact clay loam or clay which changes abruptly at a depth of 20 or 24 inches into less compact lighter-textured material. Bedrock, which lies at an average depth of about 26 inches, consists largely of coarse-textured sandstone, though in places it is bluish-gray shale. The sedimentary rock lies over igneous or metamorphic rocks, and in places the underlying rocks outcrop on the surface and the soils are more nearly like soils of the Konokti series. These included areas are widely scattered and are of irregular extent and occurrence. Some small areas, in which transported material belonging to the Pinole soils overlies the Hugo soil material, have also been included in mapping.

Most of this shallow soil occurs in the northwestern part of the area. A body embracing several square miles extends northward from a point about 2 miles north of Lakeport. Several smaller bodies occur in the same vicinity, and one very small body is at Lower Lake.

The areas range from rolling to hilly. The numerous drainage ways provide good or excessive drainage throughout the soil.

The shallow phase of Hugo clay loam is largely grass covered, with a few stunted oaks in areas having better moisture supply. It is valued only for the grazing it affords.

AIKEN CLAY LOAM

The surface soil of Aiken clay loam to a depth ranging from 4 to 7 inches consists of red or dull brownish-red clay loam which is firm and dense when dry but somewhat granular when broken up or when moist. The surface soil contains very little organic matter. In local areas some angular gravel are present, though generally

not in sufficient quantity to interfere with cultivation. The subsoil is red clay loam or clay which generally becomes somewhat heavier with depth until it grades rather abruptly into partly weathered parent bedrock lying at an average depth of about 45 inches. The subsoil is moderately compact in the upper part and becomes increasingly compact until it grades into the bedrock. The profile throughout appears quite dense, having but little visible pore space in the surface soil or upper subsoil layer.

Aiken clay loam is derived from the weathering in place of soil material derived from basalt, andesite, obsidian, or other basic igneous rocks.

This is not an extensive soil. It occurs in a number of widely scattered bodies associated with other soils, developed on consolidated bedrocks, which border the alluvial soils along Clear Lake. Two important areas are 4 miles southeast of Upper Lake, a comparatively large body borders Clear Lake near Soda Bay, and several smaller bodies are at the base of Mount Konokti.

Included with mapped areas of Aiken clay loam are a few small undifferentiated areas having calcareous subsoils. Such areas would be recognized under a distinct soil series if extensively developed. The surface soil to a depth ranging from 12 to 18 inches is red, brown, or chocolate-brown of somewhat adobelike structure. The subsoil to a depth ranging from 20 to 30 inches consists of grayish-brown or red clay loam or clay containing much partly weathered limestone rock. The subsoil is mildly calcareous as is also the surface soil in a few places. Scattered over the surface there may be a few waterworn gravel, indicating that the surface soil at least may contain some transported material. A few bodies have dark-gray or black surface soils.

Areas of Aiken clay loam are hilly or mountainous. The soil is well drained and well oxidized.

Under virgin conditions, pines, oaks, or brush form a dense vegetal cover. About 10 per cent of the land is under cultivation. Several bearing walnut groves and a number of young groves not yet in bearing are located on this soil. Prunes, some pears, and a number of other fruits as well as general farm crops are grown. The land is well suited to agriculture and is valued rather highly.

The soil can be maintained in a productive state by turning under organic matter and by observing good cultural practices.

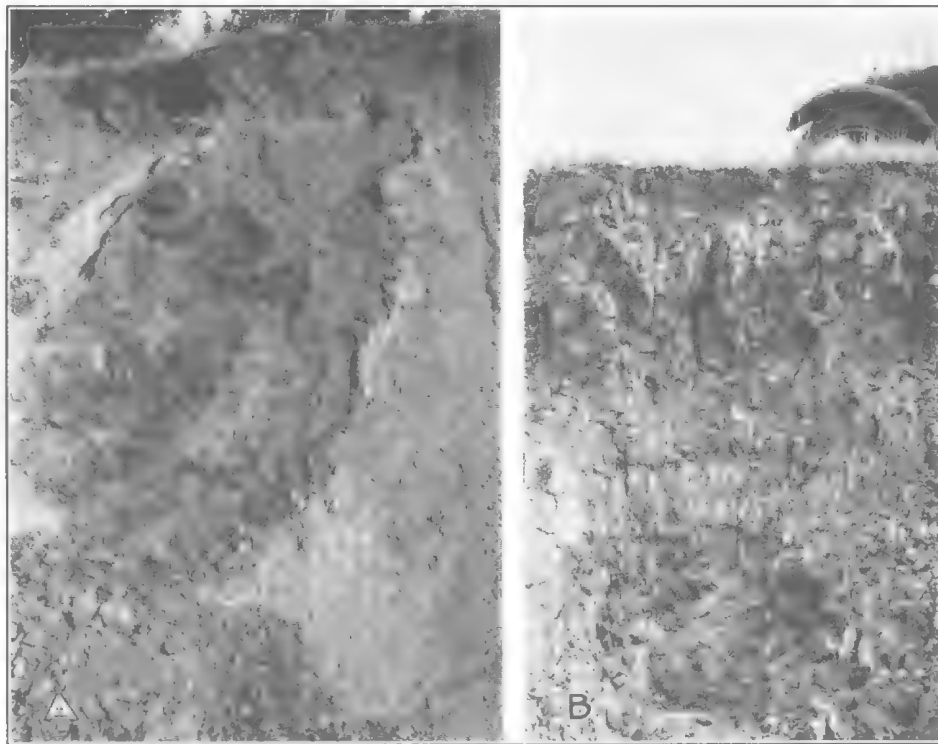
The calcareous-subsoil inclusion is not utilized for agricultural purposes. It borders the eastern end of Clear Lake and a large proportion of it is subdivided for residential purposes.

AIKEN GRAVELLY CLAY LOAM

The 4 to 6 inch surface soil of Aiken gravelly clay loam is red, dull-red, or brownish-red loose, friable, granular gravelly clay loam, which under cultivation becomes lighter textured. Most of the gravel are 2 inches or less in diameter, and they consist of angular fragments of the parent rock. The upper subsoil layer is red or brownish-red moderately compact gravelly clay loam or clay to a depth ranging from 14 to 20 inches. The deeper subsoil layer to a depth ranging from 30 to 40 inches consists of red very compact gravelly clay loam or clay which is firm and dense and lacks notice-



A, One of the older pear orchards on Rincon loam; B, view of soil surface showing shrinkage cracks formed during dry summer season in Clear Lake clay adobe



A, Soil profile showing characteristic jointed structure in compact-subsoil horizon of Rincon very fine sandy loam;
B, soil profile of Klamath silty clay loam

able structural partings. This material changes abruptly to red moderately compact gravelly heavy-textured material containing many fragments of the parent rock on which the subsoil rests at a depth ranging from 45 to 60 inches.

The soil is developed by weathering in place from andesite, basalt, or other basic igneous rock. In local areas the bedrock outcrops or occurs at a slight depth, but, in general, the soil is deeply weathered and well suited to agriculture.

Areas of this soil occur in a number of bodies near Lower Lake, and small areas occur in the mountainous section northeast of that place. A large body is 3 miles northeast of Clear Lake Oaks. Bordering Konokti Bay and at various other places near the base of Mount Konokti the soil occurs in bodies ranging from a few acres to 3 or more square miles.

The land ranges from rolling to hilly or mountainous. The soil is well drained and well oxidized.

Under virgin condition the land is forested with pine and oaks or covered with a dense growth of brush. About 10 per cent of the land is under cultivation and is used largely in the production of walnuts, prunes, grapes, and general farm crops. Walnuts offer considerable promise on this soil. Groves from 12 to 15 years old yield from 1,200 to 1,500 pounds to the acre. Wheat and barley are the principal general-farm crops grown, and fair yields are obtained.

Unimproved soil of this kind is held at prices ranging from \$10 to \$20 an acre. Improved land is valued at \$150 or more an acre, depending on the nature of the improvements.

Aiken gravelly clay loam is a productive soil and can be used more extensively in the production of fruit and nuts. On the steeper areas care must be exercised to prevent erosion when the land is under cultivation.

Aiken gravelly clay loam, stony phase.—The stony phase of Aiken gravelly clay loam consists of brownish-red or red stony gravelly clay loam to a depth of 6 or 8 inches. The stones are generally 8 or 10 inches in diameter and consist of angular fragments of the parent rock. They will have to be removed before cultivation of the ground can take place. The subsoil consists of moderately compact stony gravelly clay loam or clay which is somewhat redder than the surface soil. At a depth ranging from 30 to 45 inches the subsoil grades into bedrock of andesite, basalt, or obsidian. Much of the stone in the soil is obsidian.

Soil of this phase occurs mainly in one area about 2 miles south of Konokti Bay. A few small bodies occur elsewhere throughout the mountainous parts of the area.

The land ranges from rolling to hilly or mountainous, and drainage is well developed.

Under virgin conditions this stony soil is covered with a dense growth of brush or scattered oaks and pines. It is not developed for agriculture at present, owing to the cost of clearing the land and of removing the stones. The weathered soil material is shallower than in typical Aiken gravelly clay loam, and it has a much lower agricultural value.

BAYSIDE SILTY CLAY LOAM

The surface soil of Bayside silty clay loam to a depth of 8 or 10 inches consists of dull brownish-gray or dull-gray silty clay loam mottled with rust brown. When dry the material becomes lighter gray. The subsoil to a depth of 72 or more inches is dull brownish-gray, dark brownish-gray, or dark-gray stratified clay loam or clay mottled with rust brown. Both surface soil and subsoil contain a high proportion of organic matter. In some bodies of this soil, particularly those occurring 2 miles west of Upper Lake, a peaty layer from 4 to 10 inches thick is generally reached at a depth ranging from 18 to 36 inches.

The total area of this soil in the Clear Lake area is approximately 3 square miles. Most of it is developed in reclaimed lake bottoms or in lake beds which at present are dry in summer and marshy or wet during the winter. A large body is 1 mile south and another is 2 miles west of Upper Lake. Three small bodies occur in this same general locality 2 miles northeast of the town. A number of bodies are in the mountainous section of the south-central part of the area. A typical body is at Salminas Resort, and several smaller areas occur northwest of that place.

Approximately 60 per cent of the land is under cultivation, and uncultivated areas are used as grazing lands. Under cultivation the soil is used principally in the production of string beans, though a number of other vegetables, including dry beans, potatoes, cabbage, and onions, together with barley and oats, are produced in a small way.

This is a productive soil, and it is generally well farmed. In the reclaimed areas bordering Clear Lake the position of the water table is so regulated as to provide subirrigation. Yields of the different crops are generally heavy and the soils are valued highly. A local cannery handles all the string beans produced in the area.

Bayside silty clay loam, calcareous-subsoil phase.—The calcareous-subsoil phase of Bayside silty clay loam is characterized by a brownish-gray silty clay loam or silty clay surface soil to a depth ranging from 8 to 12 inches. The surface soil contains much organic matter and is mottled with rust brown. The subsoil to a depth ranging from 24 to 36 inches is dull brownish-gray clay loam which also contains much fine silty material and organic matter and is mottled with rust brown. The lower subsoil layer, which continues to a depth of 72 or more inches, is dark-gray or dull brownish-gray stratified calcareous clay or clay loam mottled with yellow or rust brown. Organic matter is very plentiful throughout the soil.

Soil of this phase occupies slightly elevated benches or terraces adjacent to Clear Lake. The benches, if not protected by dikes, are under water from time to time during the wetter periods of the year. A large body of the soil is about 1 mile northwest of Lower Lake. Other areas somewhat broken by narrow strips of other soils occur one-half and $1\frac{1}{2}$ miles south of Upper Lake.

At present adequate drainage is effected by artificial means over a part of the land. However, a large part remains poorly drained.

About 20 per cent of the land is under cultivation, and the remainder is valued highly as pasture land for dairy cattle. Alfalfa and vegetables, including string beans, potatoes, and onions, are grown.

Alfalfa yields from 3 to 4 or more tons an acre and potatoes from 150 to 200 bushels, sometimes as much as 300 bushels.

On account of its high organic-matter content, the soil is easily handled. It is generally well farmed and is highly productive.

BUTTE GRAVELLY SAND

The surface soil of Butte gravelly sand consists of gray or dark-gray loose friable gravelly coarse sand from 5 to 8 inches thick. Most of the sand particles are sharp and angular. The subsoil, to a depth of 16 or 20 inches, is gray or yellowish-gray gravelly coarse sand which is but slightly compacted. Directly overlying bedrock, which occurs at an average depth of about 26 inches, the material consists largely of gray partly weathered fragments of the parent rock. The soil is derived largely from weathered pumice or basic tuffaceous rocks.

As mapped the soil includes a small body of loam or clay loam texture, lying 1 mile southeast of Kelseyville. The subsoil of this included soil is generally heavier than the surface soil and checks badly on drying. The weathered soil is shallow, in most places ranging from 20 to 36 inches in depth.

Butte gravelly sand is developed in a number of small scattered bodies throughout the central and eastern parts of the area, the largest lying near Clear Lake Park. A number of smaller areas lie near the base of Mount Konokti and in the mountains to the south.

The soil occupies undulating or hilly areas in which drainage is well developed.

Most of the land supports a dense growth of brush, which renders it of little value for grazing purposes. With the exception of about 5 acres of the soil which is planted to prunes, the land is not developed for agriculture. Areas in the vicinity of Clear Lake, which may be used as building sites, have a higher sale value than their agricultural possibilities warrant. In general the land has little or no agricultural value.

KLAMATH SILTY CLAY LOAM

Under virgin conditions the 1 or 2 inch surface layer of Klamath silty clay loam is dull brownish-gray or dark-gray clay which under field conditions is of very smooth silty clay loam texture. The material has a flaky appearance until disturbed, when it crumbles readily into small granules. The subsurface layer to a depth ranging from 4 to 7 inches is dark brownish-gray firm material of similar texture which breaks up under cultural operations into small clods or granules. The material contains appreciable pore space, thereby allowing free movement of air or moisture. The upper subsoil layer to a depth ranging from 15 to 20 inches is dark-gray clay or clay loam which is moderately compact and dense, containing little or no pore space. The underlying material to a depth of slightly more than 36 inches is light brownish-gray compact dense clay loam or clay containing appreciable vertical root cavities which are coated with dark-brown colloidal material carried by percolating water from the surface soil into the subsoil. The substratum

to a depth of 72 or more inches consists of extremely compact bluish-gray dense waxy clay. The substratum is very high in colloidal material, and when dry it checks into columns from 3 to 4 inches in diameter. (Pl. 2, B.)

As mapped, Klamath silty clay loam includes several bodies of gravelly texture, which are shown on the accompanying soil map by gravel symbols. The gravel interfere somewhat with cultural operations, and tend to make the soil dry out more quickly than the typical soil. Such areas occur largely on the alluvial fan northeast of Kelseyville. Two small bodies of like character are in the south-central part of the area, one 3 miles north and the other 5 miles northwest of Seigler Springs. Northeast of Kelseyville is an included area in which the surface soil and subsoil, to a depth ranging from 36 to slightly more than 40 inches, are loose and friable and are favorable to cultural operations and the development of plant roots. Two small areas lying 3 miles northeast of Kelseyville have calcareous surface soils and subsoils.

The principal areas of Klamath silty clay loam lie northeast of Kelseyville, and a number of small bodies occur in widely separated places throughout the south-central and eastern parts of the area.

The soil occupies basinlike areas and flat poorly drained depressions bordering stream courses. It generally occurs in positions in which drainage conditions can not be improved, and during the wetter months of the year most of the soil is covered with water.

About 50 per cent of the land, constituting the better-drained areas, is under cultivation. Under virgin conditions the soil is covered with native grasses or weeds and is used as grazing land. The cultivated areas are used largely in pear production, with a small acreage used for barley and oats.

The only fertilization given Klamath silty clay loam is the turning under of the winter growth of grasses and weeds. The soil is in need of drainage, though it is doubtful if drainage would pay, even if it were possible, in many of the basinlike areas, on account of the tightness and imperviousness of the subsoil.

Klamath silty clay loam, gravelly phase.—The 6 or 8 inch surface soil of the gravelly phase of Klamath silty clay loam consists of gray or dark brownish-gray gravelly sandy loam. The upper part of the subsoil to a depth ranging from 26 to 30 inches is dark-gray gravelly loam which is moderately compact and, on drying, cracks into coarse clods. The lower part of the subsoil to a depth of 72 or more inches consists of very compact dense bluish-gray or drab gravelly clay or clay loam. The material in this layer retards the movement of air or moisture, and it is seldom penetrated by plant roots.

Areas of the gravelly phase are inextensive. Most of them occur in basinlike poorly drained depressions. The largest area is about $1\frac{1}{2}$ miles south of Konokti Bay. One small body occurs 1 mile east of Kelseyville and two others lie near the base of Mount Konokti, about 4 miles southeast of Kelseyville.

Soil of this phase is not valued highly for agriculture. A very small acreage is under cultivation in connection with adjoining soils and is used in the production of prunes and general farm crops. The

yields obtained are generally low. Uncultivated areas are covered with grass and used for grazing, for which purpose the soil seems best suited.

HOLCOMB CLAY LOAM

The surface soil of Holcomb clay loam to a depth of 8 or 10 inches consists of brown, light-brown, or light yellowish-brown firm dense clay loam which under cultivation works up to a cloddy structure. The upper subsoil layer, which extends to a depth ranging from 20 to 26 inches, is brown or light reddish-brown clay loam or clay which cracks into coarse clods when disturbed. The lower subsoil layer to a depth ranging from 30 to 36 inches is dull reddish-brown or reddish-drab heavy plastic clay which checks, on drying, into columns or blocks 4 or 5 inches in diameter. This layer is underlain to a depth of 72 or more inches by bluish-gray dense waxy clay which also breaks into a coarse columnar structure.

In a few areas the surface soil and upper subsoil layer contain a moderate amount of small angular or subangular gravel, most of which are less than 1 inch in diameter and do not interfere with cultural operations.

Holcomb clay loam occurs in flat areas, most of which are subject to poor subdrainage or to seepage from higher-lying soils. The largest body is 2 miles east of Middletown, and small areas are 2 miles northwest and 3 miles northeast of Middletown. Typical areas of the soil occur in the vicinity of Burns Valley School just north of Clearlake Highlands, and a small body is 2 miles south of that place.

The soil is not valued highly for agriculture. Less than 2 per cent of the land is under cultivation, and the remainder is covered with grass, together with a few oak trees, and is used as grazing land. The cultivated areas are devoted largely to grain production. Recently a small body of the soil has been planted to pears.

The soil has little potential value for agriculture, owing to the slowness with which water moves through it or is given up to crops by the heavy subsoil. The best utilization of the land is for grazing purposes.

ROUGH MOUNTAINOUS LAND

Rough mountainous land consists of areas so rough, broken, and mountainous as to render them generally unsuited to any form of agricultural development. Many of the areas are practically inaccessible, and the expense of detailed mapping is not warranted. However, small isolated areas on which crops might be grown may be included with this material.

The soils are, with possibly a few exceptions, developed on weathered bedrock materials, and if mapped in detail would be classified in the Aiken, Konokti, or Hugo series. In addition to the unfavorable mountainous relief, the rough mountainous land is, in general, shallow, stony, and otherwise unfavorable to agriculture.

Rough mountainous land, which includes the most extensive soil material of the area, occupies the rougher marginal and southern parts. In the southern and southeastern parts, most of the land is

forested with pines and a few oaks and is valued for grazing. Elsewhere the vegetation consists largely of brush, rendering such areas of little or no grazing value.

ROUGH STONY LAND

Rough stony land consists of areas too rough and stony to be of any value for agriculture. As mapped in the Clear Lake area, some bodies of the material, although extremely stony, are not particularly rough. If more extensive, such bodies would be recognized as scab land, a stony nonagricultural material mapped elsewhere in California.

Most of the rocks occurring in this material are serpentine, and a few are andesite. In local areas a soil covering from 2 to 20 inches thick may be found in which grasses flourish in the spring and early summer, affording good grazing for sheep and cattle. Many bodies are bare of vegetation during the summer, though most of the land supports a dense growth of brush which renders it valueless as grazing land. With future soil developments some small undifferentiated bodies of agricultural land may be found associated with this material, particularly on Mount Konokti. Such areas are practically inaccessible at present and could not be mapped separately.

Rough stony land occurs principally on the east of Mount Konokti. A great number of bodies are mapped elsewhere throughout the area.

RIVER WASH

River wash is a nonagricultural class of miscellaneous materials consisting of loose, porous deposits of sand, gravel, and cobbles, and lying only a few feet above normal stream flow. During periods of high water it is overflowed for weeks at a time. The material does not support any form of vegetation except an occasional clump of willows, and it has no value either for grazing or for agriculture.

River wash is inextensive. A few bodies occur along Middle, Kelsey, Adobe, and Scott Creeks, and a small body borders Clear Lake near Sulphur Banks. A great number of small bodies occur on Putah Creek and its tributaries in the southeastern part of the area.

SOILS AND THEIR INTERPRETATION

The Clear Lake area is located in the coastal mountains of west-central California. The soils, therefore, have been developed under the distinctive climatic conditions of hot, dry summers and cool, moist winters. They are wet during the cooler months and are subject to a certain amount of leaching; they are seldom frozen and then only to a slight depth and for a short time. Arid conditions prevail during the four summer months, which average less than an inch of rainfall, the soils dry out, and the herbaceous vegetation dies. On decaying, the plants leave many small root cavities which promote aeration, drainage, and bacterial life. Under these climatic and botanic conditions, the normally developed soils of the area are characterized by the absence of accumulated lime, noticeably permeable A and B₁ horizons, and moderately compact, less permeable B₂ horizons.

Local variations in climate and vegetation have been responsible for some of the differences between the soils of the area. Rainfall commonly increases toward the southwest with elevation and degree of exposure. Associated with the forest cover of the more elevated localities are extensive bodies of reddish soils of the Aiken series. Poor drainage conditions are characteristic of several bodies of low-lying soils bordering Clear Lake and these support comparatively heavy growths of water-loving plants; in these localities, which are favorable to the accumulation of organic matter, the soils are mainly dark colored. Some of the dark soils are calcareous (Clear Lake soils), others (Dublin soils) are not. The lime content in the Clear Lake soils has apparently accumulated from the ground water that has moved downward from better-drained, higher-lying areas. The well-drained mature and immature soils of the Clear Lake area commonly occupy the low-lying hills and ridges. Most of these are brown, pale red, or somewhat yellow. The reddish color is more pronounced in the B horizon owing largely to an accumulation of iron oxides. Where not so well drained, the subsoils and in many places the surface soils, are predominantly gray or grayish brown. Under poor drainage the subsoils show a rust-brown mottling even in the recently deposited soils. In places the subsoils may be bluish gray or green, owing to restricted aeration which has been caused by very poor drainage or by the presence of an overlying impervious clay layer.

Many of the soils, particularly those that have been developed in place from consolidated materials, have obviously been influenced by the kind of rock from which they are derived. The highly siliceous and sharp, angular particles of Butte gravelly sand are traceable to the pumiceous and highly siliceous character of the parent material.

According to age or stage of development, the soils of the Clear Lake area may be classified as young, youthful, immature, or mature.² The young soils include those of the Clear Lake, Dublin, Yolo, and Bayside series. The soils of this group show little or no evidence of weathering; the subsoils are generally stratified and similar in structure to the surface soils. The Clear Lake soils are differentiated from the Dublin soils by the presence of lime in the first-named soils; soils of both series are dark gray or black, and they occur under poor drainage. Soils of the Yolo series are well drained and probably will develop, with further weathering, into the Rincon soils of the immature group. Some bodies included with the Yolo soils as poorly drained phases occur under poor drainage and have somewhat mottled subsoils. Soils of the Bayside series are essentially recently emerged or reclaimed lake or marsh lands. These soils are mottled and contain much unchanged organic matter.

The youthful soils, as recognized in the Clear Lake area, include soils of the Aiken, Konokti, Hugo, and Butte series. It is not probable that these soils, the product of weathering in place of consolidated bedrock materials, are younger in point of time than any other soil of the area, but, owing to the progressive and continued removal of the surface soil by erosion, they have a feebly developed

² SHAW, C. F. A DEFINITION OF TERMS USED IN SOIL LITERATURE. First Internat. Cong. Soil Sci. Proc. and Papers, 1927: 38-64. 1928.

illuviated horizon, and the eluviated horizon shows but little effect of the vegetal cover. The red soils of the Aiken series commonly show a better-developed illuviated horizon than do the browner soils of the Konokti series. Soils of both series are derived from the same kind of rock, but differences in the stage of weathering and in oxidation probably account for the redder color of the Aiken soils. Soils of the Hugo series are differentiated from other soils of this group because of their light grayish-brown or yellowish-brown color and the presence of a more compact illuviated horizon. As they occur in localities of probably lower rainfall than do soils of the Aiken and Konokti series, this characteristic subsoil feature may be ascribed to diminished surface erosion and less leaching. Soils of the Butte series, the fourth member of this group, differ in origin, color, and structure from the other three. They are derived from pumiceous and tuffaceous rocks and contain much sharp angular volcanic material. They show little evidence of weathering.

The immature group includes soils of the Rincon series, which have normally developed profiles, and soils of the Cole, Holcomb, and Klamath series, all of which have abnormally developed profiles. The soils of this group show a markedly compact and somewhat heavier-textured subsoil horizon. The profile of Rincon very fine sandy loam, a representative soil of the series, is presented in detail in a subsequent paragraph. The soils of the Cole series differ from the Rincon soils in having a substratum of lacustrine material and in containing mottlings of yellow and rust brown as a result of poor subdrainage. Soils of the Holcomb series have also been developed under poor drainage, and the illuviated horizon is very pronounced. These soils are subject to considerable seepage from higher lands. The Klamath soils occur in undrained basin-like areas. The surface soils are gray and the subsoils, which are very tight and heavy textured, are similar to those of the Holcomb soils except that they differ markedly in color.

The group of mature soils includes soils of the Manzanita and Pinole series. Soils of the Manzanita series are pale reddish brown or brownish red, whereas those of the Pinole series are light brown or light grayish brown with a decided yellowish cast. The soils of both series have very pronounced illuviated horizons as is indicated in the detailed description in a subsequent paragraph on Manzanita clay loam, the profile of which is typical both of the series and of the normally developed, mature soils of the Clear Lake area.

Under virgin conditions, the typical profile of Rincon very fine sandy loam is representative of a normally developed, immature soil of this locality. The surface (A_1) horizon consists of $1\frac{1}{2}$ or $2\frac{1}{2}$ inches of pale yellowish-brown or light grayish-brown granular fine sandy loam. The granules are somewhat smaller than a pea, are generally rounded, and are of uniform color throughout. The A_2 horizon to a depth ranging from 8 to 12 inches is light-brown or light grayish-brown fine sandy loam which is firm but breaks up readily to a small granular structure. This horizon has appreciable pore space. The cavities contain a small residue of partly decayed organic matter, but they do not show any colloidal deposition. The A_1 horizon changes very abruptly into the A_2 horizon.

The change from the A_2 horizon to the B_1 horizon is transitional. The B_1 horizon extends to a depth ranging from 24 to 34 inches, where it changes gradually into the B_2 horizon. The upper illuviated horizon, however, consists of moderately compact fine sandy loam or loam having a great amount of pore space left by the decay of plant roots or by burrowing animals. The individual cavities show a very slight dull-brown colloidal deposition on their inner surface. When disturbed the material in this horizon breaks up to a small cloddy structure. The lower illuviated, or B_2 , horizon consists of dull-brown or dull grayish-brown very compact loam or clay loam to a depth ranging from 60 to 70 inches. The material contains little or no visible pore space. When exposed in cuts it shows a slightly developed lenticular or small cubical structure. The cracks are coated with a dull-brown colloidal deposition. When broken the material becomes of coarse cloddy structure. (Pl. 2, A.) Broken fragments or clods in this horizon show a uniform dull grayish-brown color extending to the immediate surface, where the colloids give the material a dull or dark-brown stain. The C_1 horizon to a depth of 90 or more inches consists of light-brown or light grayish-brown loam or heavy fine sandy loam which is amorphous. The material contains a few root cavities.

The profile of Manzanita clay loam is representative, in the Clear Lake area, of a mature soil which has been normally developed under virgin conditions. It has a 1 or 2 inch surface (A_1) horizon of light-reddish or brown granular loam, in which the granules are small and incoherent. The horizon contains an appreciable quantity of grass roots and iron concretions. The concretions are about the size of buckshot, well rounded, and apparently built up in concentric layers. They are reddish-brown on the surface grading to bluish gray in the center. The A_2 horizon to a depth of 6 or 8 inches is pale reddish-brown, pronounced reddish-brown, or brownish-red firm heavy loam which breaks up to a small granular structure under slight pressure. Owing to a great number of pore spaces, the horizon is permeable to air and moisture. Iron concretions in the form of shotlike pellets are fairly numerous, but under cultivation they disappear. The upper illuviated, or B_1 , horizon is reddish-brown or brownish-red moderately compact heavy loam or clay loam to a depth ranging from 22 to 28 inches. Iron concretions are numerous in this layer. It contains a moderate amount of pore space, the individual cavities being coated with a dull reddish-brown colloidal deposition. When disturbed the material of this horizon breaks into clods which may be easily broken down to a medium granular structure under slight pressure. The B_2 horizon consists of red or brownish-red very compact gravelly clay loam or gravelly clay to a depth ranging from 38 to 44 inches. The material contains but little pore space, is dense, and breaks down to a cloddy structure. The gravel are coated with dull reddish-brown colloidal material, and they are weathered to the extent that they can be cut through with a spade or other sharp instrument. Few or no iron concretions occur in this horizon. The B_3 horizon to a depth ranging from 65 to 75 inches is pale-red dense extremely compact clay loam or clay containing a great quantity of well-weathered gravel which are completely coated with colloidal material. They can be readily bored

through and when brought up on a soil auger give to the soil a yellow, red, brown, and gray mottling. The material is dense and breaks up into coarse clods. The parent material, or C_1 horizon, to a depth of 90 or more inches is pale-red or pale yellowish-red very compact dense gravelly clay loam. The gravel are well weathered but do not show so much colloidal deposition as is common to the overlying material. A gradual transition from one horizon to another occurs except between the A_1 and A_2 horizons, where the line of demarcation is very sharp.

The mechanical analysis, the ultra clay content, and the pH value of several of the more important soils in the Clear Lake area are presented in Table 4. The mechanical analyses were made by the division of soil technology, University of California, according to the long-established official method of the United States Bureau of Chemistry and Soils, except that the percentage of clay was determined directly by weighing and not by difference. The determination of the content of ultra clay was made as follows: Air-dry soil was shaken for 24 hours with 1 per cent sodium carbonate as a deflocculent, then made up to a volume of 500 cubic centimeters, and allowed to stand for 24 hours in a tall cylinder. Samples were taken from the depth of 7.72 centimeters and represent, by Stokes' law, particles of 1 micron effective diameter and smaller. The clay reported includes the particles from 1 to 5 microns and was obtained by subtracting the ultra clay from the total clay. The hydrogen-ion concentrations were determined electrometrically in the laboratories of the Bureau of Chemistry and Soils by means of the hydrogen electrode.

TABLE 4.—*Mechanical analysis, ultra clay content, and pH value of certain soils, by horizons, in the Clear Lake area, Calif.*

Soil type and sample No.	Depth	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay	Ultra clay	Total clay	pH value
Clear Lake clay adobe:	<i>Inches</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	
577248.....	0-6	0.140	1.800	2.840	5.528	5.980	32.856	29.03	15.08	44.11	-----
577249.....	6-14	.120	.384	.620	1.612	2.800	40.252	54.90	19.44	54.34	-----
577250.....	14-72	.420	1.620	1.280	5.724	14.320	41.160	18.36	16.97	35.33	-----
Dublin clay adobe:											
577238.....	0-10	.146	1.964	2.416	4.484	6.560	44.880	24.95	15.11	40.06	-----
577239.....	10-72	.164	.270	.876	3.832	9.628	34.680	32.07	18.86	50.93	-----
Yolo gravelly loam:											
577288.....	0-10	2.952	3.608	9.824	27.160	28.592	16.036	5.79	6.18	11.97	-----
577289.....	10-72	6.712	10.676	20.524	34.316	10.080	7.144	3.70	7.05	10.81	-----
Yolo fine sandy loam:											
577266.....	0-7	.580	2.236	8.440	32.900	30.780	14.860	5.38	5.22	10.60	-----
577267.....	7-72	.760	3.440	5.140	28.820	36.000	15.744	4.88	5.87	10.75	-----
Bayside silty clay loam:											
577276.....	0-10	.500	1.744	2.020	4.920	20.064	50.016	14.35	6.87	21.22	-----
577277.....	10-72	.324	7.308	9.024	12.100	14.280	24.932	20.37	11.72	32.09	-----
Aiken gravelly clay loam:											
577210.....	0-4	1.720	5.836	3.196	12.116	20.942	27.760	16.11	12.58	28.69	-----
577211.....	4-18	4.272	5.180	2.290	5.254	10.892	30.056	32.29	9.70	41.99	-----
577212.....	18-34	.828	2.480	4.660	11.180	21.548	25.228	11.79	21.64	33.40	-----
577213.....	34-48	1.143	3.818	4.028	10.956	21.800	25.932	13.10	19.68	32.78	-----
Aiken clay loam:											
577218.....	0-6	1.782	3.656	4.826	10.128	24.556	25.176	18.36	13.45	29.81	6.75
577219.....	6-21	.898	3.908	3.470	10.300	21.480	21.840	9.36	28.84	38.20	7.13
577220.....	21-40	.948	1.324	1.692	9.242	24.936	19.692	16.39	26.03	42.42	6.82
577221.....	40+	1.676	4.108	1.320	8.888	11.500	22.872	17.86	31.88	49.74	6.89

TABLE 4.—*Mechanical analysis, ultra clay content, and pH value of certain soils, by horizons, in the Clear Lake area, Calif.*—Continued

Soil type and sample No.	Depth	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay	Ultra clay	Total clay	pH value
Konokti gravelly clay loam.	<i>Inches</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	
577214	0-6	6.890	8.400	2.986	5.600	16.360	30.832	16.16	12.90	29.06	-----
577215	6-22	6.640	5.964	4.280	5.764	16.910	28.016	15.33	17.02	32.35	-----
577216	22-34	5.174	7.280	2.808	5.064	15.350	26.856	14.35	23.00	37.35	-----
577217	34-45	6.304	6.764	2.748	5.452	10.428	30.406	18.37	19.76	37.13	-----
Hugo clay loam:											
577284	0-6	.656	1.664	2.144	7.728	29.520	36.760	13.64	8.56	22.20	6.12
577285	6-14	.532	1.640	1.084	6.620	26.580	33.020	16.69	14.52	31.21	5.75
577286	14-24	.956	1.700	1.506	5.776	21.640	27.224	16.16	26.44	41.63	4.83
577287	24-30	1.504	2.856	1.488	6.896	19.368	29.554	14.01	24.98	38.99	4.82
Butte gravelly sand:											
577295	0-7	16.644	23.800	11.202	19.798	15.848	5.148	4.63	2.88	7.01	-----
577296	7-18	13.670	16.948	16.516	22.620	17.062	7.636	3.16	1.97	5.13	-----
577297	18-27	12.892	25.172	11.742	21.736	16.620	7.570	1.70	2.22	3.92	-----
Rincon gravelly sandy loam:											
577281	0-10	19.656	15.520	6.160	15.040	14.608	13.160	7.41	7.52	14.93	-----
577282	10-44	11.676	9.600	9.780	14.908	20.080	14.476	8.19	11.80	19.96	-----
577283	44-70	5.912	7.104	4.040	16.160	26.788	15.784	8.05	16.04	24.09	-----
Rincon very fine sandy loam:											
577293	0-2½	.000	1.000	4.776	23.132	40.056	17.392	5.43	7.94	13.37	-----
577294	2½-11	.000	.568	1.216	12.900	44.340	23.684	8.41	8.86	17.27	-----
577295	11-30	.200	.320	.468	8.328	39.540	26.548	9.68	14.70	24.38	-----
577296	30-65	.000	.360	.916	10.416	33.452	27.366	10.46	16.97	27.43	-----
577297	65-90	.184	.308	.620	12.332	36.898	20.488	12.31	17.30	29.61	-----
Cole fine sandy loam:											
577234	0-7	2.116	5.548	6.324	18.400	31.748	20.088	8.52	7.47	15.99	-----
577235	7-20	2.104	3.184	7.000	21.042	29.668	16.064	18.65	12.69	21.34	-----
577236	20-40	1.316	4.116	4.968	15.634	26.680	21.600	10.57	15.54	26.11	-----
577237	40-72	2.268	3.040	5.428	21.568	27.912	17.638	6.92	15.65	22.57	-----
Holcomb clay loam:											
577201	0-10	.722	1.000	1.180	4.678	20.542	42.562	17.21	11.53	28.74	-----
577202	10-23	1.260	1.232	1.250	5.096	20.000	36.112	16.75	18.04	34.79	-----
577203	23-32	.540	1.576	1.800	5.644	18.436	32.064	24.54	15.04	39.58	-----
577204	32-70	1.084	1.616	.904	1.552	7.906	42.576	11.45	32.75	44.20	-----
Manzanita gravelly fine sandy loam:											
577227	0-7	6.152	8.652	8.170	19.868	23.428	17.662	8.64	7.51	16.15	-----
577228	7-20	6.364	7.562	10.748	19.144	20.544	15.316	8.51	11.95	20.46	-----
Manzanita clay loam:											
577254	0-1½	3.560	5.840	3.104	10.968	24.872	27.072	14.26	10.01	24.29	6.13
577255	1½-7	4.200	5.560	3.676	12.248	20.620	24.754	16.68	12.68	29.36	6.07
577256	7-26	3.052	6.672	4.276	11.072	18.308	22.076	14.90	19.36	34.26	5.85
577257	26-40	1.840	4.960	4.716	13.952	18.772	19.520	8.96	27.84	36.80	4.75
577258	40-70	1.760	4.164	7.636	16.032	21.280	20.756	5.75	22.87	28.42	4.75
577259	70-90	10.480	8.528	3.444	10.752	18.184	19.970	7.22	22.03	29.25	4.82
Pinole gravelly fine sandy loam:											
577230	0-6	5.622	5.422	10.280	25.400	31.254	13.312	4.23	4.40	8.63	-----
577231	6-30	5.708	7.488	8.386	24.962	31.692	11.070	4.08	6.59	10.67	-----
577232	30-52	23.752	15.874	11.076	8.832	7.000	7.540	6.76	19.67	26.43	-----

SUMMARY

The Clear Lake area is in the central part of Lake County, Calif., about 70 miles north of San Francisco Bay. It includes a land area of 386 square miles.

The topography is generally rough or mountainous with a narrow low-lying margin occupied by alluvial soils bordering Clear Lake and lying near the mouths of the larger streams debouching on the lake.

The average elevation of the valley lands is about 1,450 feet above sea level, and the included mountainous areas range in elevation from 2,000 to more than 4,000 feet.

Drainage is well developed except in local areas bordering Clear Lake and in a number of intermittent lakes.

Lake County was organized May 20, 1861. The population in 1920 was 5,402, and most of the people reside in the area surveyed. Lakeport is the county seat.

No railroad enters the area. Good oiled and otherwise improved roads connect with transportation points a few miles outside the area. The main traveled roads are graveled and passable throughout the year.

Pears are the principal commodity shipped from the area. Good markets are available in the Eastern States. Some of the more sensitive fruits, including figs and olives, can be grown in local areas.

The climate of the Clear Lake area is mild. The summers are comparatively warm and dry, and the winters are wet and have moderate temperatures. The mean annual temperature is 57.4° F., and the mean annual precipitation is 28.51 inches. The average annual frost-free season is 218 days, and the snowfall is light.

The soils of the area have been grouped in 14 series, embracing 21 soil types and 14 phases, in addition to 3 miscellaneous classes of nonagricultural land.

The Aiken, Konokti, Hugo, and Butte series include soils which have weathered in place on consolidated bedrock. Soils of the Aiken series are red, of the Konokti, brown, of the Hugo, light grayish brown, and of the Butte, dull gray. Aside from differences in color, these soils differ in origin and chemical and physical properties. The Aiken and Konokti series embrace soils which are largely timber or brush covered and are but slightly developed. Cultivated areas are used in the production of nuts, fruit, and general farm crops. The other residual soils are developed to less extent than the Aiken and Konokti soils.

The soils developed by weathering of old valley-filling materials are grouped in the Manzanita, Pinole, Rincon, Cole, Holcomb, and Klamath series. With the exception of the Holcomb and Klamath soils, which are poorly drained and unfavorable for crop production, the soils of this group are well utilized for agriculture. The Manzanita and Pinole soils occupy elevated terraces, and they are well weathered. These soils are used largely in fruit production. The soils of the Rincon series are well drained, and most of them are highly developed. They are light-brown soils, which are differentiated from the Cole soils on the basis of subdrainage which is poorer in the last-named soils.

The recent-alluvial soils occupy stream bottoms and, with the exception of the heavier-textured poorly drained soils, are loose and friable to a depth of 6 or more feet. They are grouped in the Clear Lake, Dublin, Yolo, and Bayside series. Soils of the Clear Lake and Dublin series are dark gray or black, and are poorly drained. Soils of the Clear Lake series are characterized by calcareous subsoils, whereas soils of the Dublin series contain no lime. The Yolo series includes light-brown well-drained soils which are used in the production of all crops suited to this region. Several poorly drained phases of the Yolo soils are mapped. The soils of the Bayside series are brownish gray, and they consist of recently

emerged or reclaimed lake-bottom lands containing much organic matter. They are valued for truck gardening.

The nonagricultural miscellaneous materials are rough stony land, rough mountainous land, and river wash.

The first white men to enter the Clear Lake area were hunters and trappers. The early agriculture consisted largely of livestock raising and general farming. Fruit growing began to assume importance as early as 1868. The production of pears, prunes, walnuts, and grapes is now the leading agricultural industry. Dairying and the production of wheat, barley, and oats are less extensively carried on. Fruit and nuts yield well, and their production is becoming more important, whereas livestock raising is becoming less important from year to year.

The farm buildings are modern and in good repair. Tractors, trucks, and automobiles are in general use and are largely supplanting horses on the farms.

Labor is plentiful. It is largely American born and efficient.

The fruit ranches are of medium size or small. General-farming operations are carried on on ranches ranging in size from 300 to 1,000 acres. The average size of farms in Lake County is about 300 acres.

Soils of the Clear Lake area seem best suited to the production of pears and walnuts, and to dairy farming.



[PUBLIC RESOLUTION No. 9]

JOINT RESOLUTION Amending public resolution numbered eight, Fifty-sixth Congress, second session, approved February twenty-third, nineteen hundred and one, "providing for the printing annually of the report on field operations of the Division of Soils, Department of Agriculture."

Resolved by the Senate and House of Representatives of the United States of America in Congress assembled, That public resolution numbered eight, Fifty-sixth Congress, second session, approved February twenty-third, nineteen hundred and one, be amended by striking out all after the resolving clause and inserting in lieu thereof the following:

That there shall be printed ten thousand five hundred copies of the report on field operations of the Division of Soils, Department of Agriculture, of which one thousand five hundred copies shall be for the use of the Senate, three thousand copies for the use of the House of Representatives, and six thousand copies for the use of the Department of Agriculture: *Provided*, That in addition to the number of copies above provided for there shall be printed, as soon as the manuscript can be prepared, with the necessary maps and illustrations to accompany it, a report on each area surveyed, in the form of advance sheets, bound in paper covers, of which five hundred copies shall be for the use of each Senator from the State, two thousand copies for the use of each Representative for the congressional district or districts in which the survey is made, and one thousand copies for the use of the Department of Agriculture.

Approved March 14, 1904.

[On July 1, 1901, the Division of Soils was reorganized as the Bureau of Soils, and on July 1, 1927, the Bureau of Soils became a unit of the Bureau of Chemistry and Soils.]

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